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Technical Assistance to the Cities of Cayce and West Columbia, and Lexington County, South Carolina

CSI Resource Systems, Inc.
Boston, MA

Prepared for

Environmental Protection Agency
Atlanta, GA

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The report presents the results of technical assistance to the City of Cayce, South Carolina, in conjunction with the City of West Columbia and Lexington County, South Carolina, in the area of Solid Waste Management. A site visit was made on January 21, 1980, to identify the major solid waste disposal problems within the jurisdiction of Cayce, West Columbia, and Lexington County. On the basis of this meeting, the following study objectives were defined:

1. Review current disposal operations and evaluate alternatives for increasing the life of the major existing landfills (Lexington County landfill);
2. Evaluate possible uses of this landfill site after closure;
3. Conduct preliminary evaluation of materials recovery from the County -- Wide Solid Waste Stream; and
4. Assess future solid waste disposal alternatives.

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345 Courtland Street, NE
Atlanta GA 30308

November 1980

Solid Waste

EPA

A TECHNICAL ASSISTANCE PROGRAM REPORT

TECHNICAL ASSISTANCE TO THE CITIES OF CAYCE, AND WEST COLUMBIA, AND LEXINGTON COUNTY, SOUTH CAROLINA

REPRODUCED BY
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Technical assistance by personnel teams. 42 USC 6913

RESOURCE RECOVERY AND CONSERVATION PANELS

SEC. 2003. The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as "Resource Conservation and Recovery Panels") to provide States and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local governments.

This report has been reviewed by the Project Officer, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Project Officer: Elmer G. Cleveland

U.S. ENVIRONMENTAL PROTECTION AGENCY

TECHNICAL ASSISTANCE PROGRAM REPORT SERIES

TECHNICAL ASSISTANCE TO THE CITIES OF CAYCE, AND WEST COLUMBIA, AND LEXINGTON COUNTY, SOUTH CAROLINA

PREPARED FOR:

OFFICE OF SOLID WASTE MANAGEMENT

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION IV, ATLANTA, GEORGIA

BY:

ENGINEERING-SCIENCE, INC.
ATLANTA, GEORGIA

AND

CSI RESOURCE SYSTEMS, INC.
BOSTON, MASSACHUSETTS

NOVEMBER, 1980

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CHAPTER 1
SUMMARY AND CONCLUSIONS

The city of Cayce, South Carolina, in conjunction with the city of West Columbia and Lexington County, South Carolina, requested technical assistance from the U.S. Environmental Protection Agency (EPA) Region IV in the area of solid waste management. A program has been established by EPA under provisions in the Resource Conservation and Recovery Act of 1976 (RCRA) whereby EPA, in conjunction with selected engineering consultants, offers technical assistance to local governments to assist them in the proper management, disposal, and/or recovery of solid waste.

As a result of the request for technical assistance, a site visit was authorized by EPA, and made on January 21, 1980. During this visit, a meeting was held with representatives of the three local governments to identify the major solid waste disposal problems within the jurisdictions of Cayce, West Columbia, and Lexington County. On the basis of this meeting, the following study objectives were defined:

- Review current disposal operations and evaluate alternatives for increasing the life of the major existing landfill (Lexington County landfill).
- Evaluate possible uses of this landfill site after closure.
- Conduct preliminary evaluation of materials recovery from the county-wide solid waste stream.
- Assess future solid waste disposal alternatives.

In the remainder of this chapter, the study findings and conclusions are summarized.

Solid Waste Quantity

Lexington County has been weighing solid waste disposed of in the county landfill since the installation of scales in October 1979.

A summary of the weight records are presented in Chapter 2 (See Table 2.1). On the average, 13,766 tons per month of solid waste are generated. This total represents a per-capita waste generation rate of 7.1 pounds per day based on current population estimates. The per capita generation rate is a rough approximation due to the estimation of service area population.

The approximate breakdown of source of generation is as follows:

City	13%	- (includes Cayce, W. Columbia, Lexington, Springdale, and Swansea)
Green Box (county)	10%	
Private	1%	
Commercial and Industrial	65%	
Franchised	6%	
Miscellaneous	5%	

Existing Disposal System

Lexington County currently operates three landfill sites. The location of the three sites is presented in Chapter 3 (see Figure 3.1). The main landfill, referred to as the Lexington County #1 landfill, the 321 landfill, or the Cayce landfill, was studied under the scope of this project.

The Lexington County landfill is located in an abandoned sand pit. On the basis of a preliminary review of the site, the following site-related problems were identified:

- Unfavorable soils conditions because of highly permeable, coarse grained underlying soils.
- Rapid percolation of leachate through the highly permeable sand materials that both underlie the site and are used for landfill cover.
- Potential for lateral migration of leachate and landfill gases.
- Contamination of groundwater and surface water.

On the basis of visual observations made at the site, discussions with South Carolina Department of Health and Environmental Control

(SCDHEC), a review of landfill inspection forms, several operation-related problems were identified:

- No engineering report, detailed plans, or detailed systematic operating plan have been developed for the landfill.
- Leachate control.
- After-hour scavenging.
- Disposal of unacceptable waste.
- Miscellaneous:

-dust	-exposed waste
-blowing litter	-surface erosion
-stabilization	-inadequate cover.

Alternative Methods for Extending Landfill Life

An estimate of the landfill's remaining usable life was made using available information and basic assumptions. Based on the current method of operation, approximately 9.7 acres are consumed per year. This translates to an estimated remaining usable life of 6 to 8 years.

Several methods of extending the usable life of the landfill were identified, including:

- Solid waste volume reduction.
- Increased area utilization resulting from adoption of systematic operating plan.
- Increased area utilization resulting from alternative land-filling method.
- Restriction of non-county usage of landfill.

These options are presented in detail in Chapter 4. The estimated technical potential for success for each option is summarized in Table 1.1.

Potential Use of Site After Closure

The landfill site was purchased by the cities of Cayce and West Columbia in 1971 with a Department of Housing and Urban Development Grant. The terms of the grant contract restrict future use of the site to open space or recreation purposes.

The planning considerations for selection of final use and closure are presented in Chapter 3. Design standards and considerations are also presented in Chapter 3.

TABLE 1.1

SUMMARY OF CONCEPTS FOR EXTENDING USABLE

LIFE OF LEXINGTON COUNTY LANDFILL

Concept	Potential for Success(1) Good	Moderate	Poor	Future Study Required
1. Solid Waste Volume Reduction				
• Mechanical Processing		X		X
• Reduced Generation			X	
• Increased Resource Recovery		X		X
2. Adoption of Systematic Operating Plan	X			
3. Alternative Landfilling Methodology	X			
4. Restriction of Noncounty Usage		X		X

(1) Refers to technical potential for extending present landfill service life. Economic comparisons with alternative disposal options have not been done.

Future Solid Waste Disposal Alternatives

Four solid waste disposal alternatives that may be available to Lexington County for future disposal are:

- A new sanitary landfill
- Incineration
- Composting
- Resource recovery.

At this time, it appears likely that landfilling will be the most feasible alternative.

Future landfill development must comply with more stringent federal environmental regulations (RCRA) and consequently will be more costly.

In order to effectively evaluate potential landfill sites for a new landfill, information must be evaluated including:

- Geologic conditions
- Hydrologic data
- Surrounding land use patterns
- Potential problems, such as leachate and gas generation
- Site access and traffic patterns
- Final land use
- Zoning restrictions.

Incineration may be a viable alternative but must be preceded by a detailed feasibility study as outlined in Chapters 5 and 6.

Composting does not appear to be a feasible disposal practice for Lexington County. In general, this practice has not been successfully used in the United States for municipal solid waste disposal.

A preliminary materials market survey was conducted in Lexington County. Based on this preliminary survey, it is concluded that markets for recovered paper, glass, aluminum, and ferrous metals exist for Lexington County. Economical recovery and sales of these materials will be dependent upon the costs associated with collection, separation, and transportation of the materials as well as the existing market conditions (in some cases highly variable).

The preliminary steps to be taken by local governments for investigaton of energy recovery feasibility are outlined in Chapter 6.

CHAPTER 2
SOLID WASTE QUANTITY

In order to effectively evaluate solid waste disposal options for Lexington County, it is first necessary to quantify the waste to be disposed of within the county. The choice of alternative disposal techniques and their associated costs are dependent upon the quantity and composition of the solid waste.

Because the Lexington County #1 landfill is the largest of three landfills serving the county, and because a weighing program has been undertaken at this landfill since November 1979, this study only addressed this landfill. Daily, weekly, and monthly weighing records obtained from Lexington County are summarized in this chapter. A summary of the solid waste generated and disposed of in the landfill is presented in Table 2.1. Per-capita waste generation rates were determined using population estimates provided by the Lexington County Department of Planning and Development (see Table 2.2). The per-capita waste generation rate is an approximation only. The service area population used in the calculation does not include the non-county users of the landfill (e.g., Richland County).

The approximate breakdown of source of generation is as follows:

City	13% (includes Cayce, W. Columbia, Lexington, Springdale and Swansea)
Green Box (county)	10%
Private	1%
Commercial and Industrial	65%
Franchised	6%
Miscellaneous	5%
Total	100%

The breakdown by source and variability of the generation of solid waste is presented in Figure 2.1. This figure is based on weekly weighing records for the period November 1, 1979, through April 30, 1980.

TABLE 2.1

SUMMARY OF SOLID WASTE DISPOSAL ESTIMATES
FOR LEXINGTON COUNTY #1 LANDFILL

Month	Solid Waste Landfilled[1]			Estimated Solid Waste Generation[4] (Pounds/day-capita)
	Tons/Month	Tons/Landfill Day[2]	Tons/Calendar Day[3]	
November 1979	14,463	603	482	7.6
December 1979	11,536	491	372	5.9
January 1980	13,990	560	451	7.1
February 1980	12,694	552	438	6.9
March 1980	14,542	619	469	7.4
April 1980	16,574	691	552	8.7
May 1980	13,313	543	429	6.8
June 1980	13,018	566	434	6.8
Average	13,766	578	453	7.1

1. Estimates based on monthly weighing records. Scales began operation in November 1979.
2. Based on 5.5 days per calendar week (landfill operates Monday through Friday and half day Saturday).
3. Tons generated per day on a 7-day-per-week basis.
4. Based on estimated 1980 service area population of 127,000.

TABLE 2.2

LEXINGTON COUNTY POPULATION

CENSUS COUNTY DIVISION	NEIGHBORHOODS	1960	1970	1975	1976	1980
Columbia Planning Area (Lexington portion (Including West Columbia)	72 thru 90	28,940	42,551	55,604	58,580	67,685
Irmo	100 and 101	1,177	5,704	9,370	10,870	13,750
Chapin	102 and 103	1,696	2,329	2,529	2,520	2,930
Lexington	104 and 105	7,884	12,297	19,980	20,850	24,990
Cayce	106 and 107	2,423	5,231	6,417	6,600	7,435
Swansea	108 and 109	4,046	4,651	4,801	4,900	5,200
Pelion	110 and 111	2,268	2,852	2,752	2,700	3,050
Gilbert	112 thru 114	4,337	4,902	4,852	4,890	5,010
Batesburg-Leesville	115	7,955	8,495	8,695	8,690	8,950
TOTAL		60,726	89,012	115,000	120,000	139,000

SOURCES:

"Population - An Analysis of the 1960 Census," Richland and Lexington Counties Joint Planning Commission, Columbia, SC, January 1964. (1960 figures).

"Population Projections in the Central Midlands Region (Fairfield, Lexington, Newberry and Richland Counties)," Central Midlands Regional Planning Council, Columbia, SC, April 1, 1975. (1975 figures).

"Population Projections for the Central Midlands Region - Fairfield, Lexington, Newberry & Richland Counties," Central Midlands Regional Planning Council, Columbia, SC, June 1977. (1970, 1976, and 1980 figures).

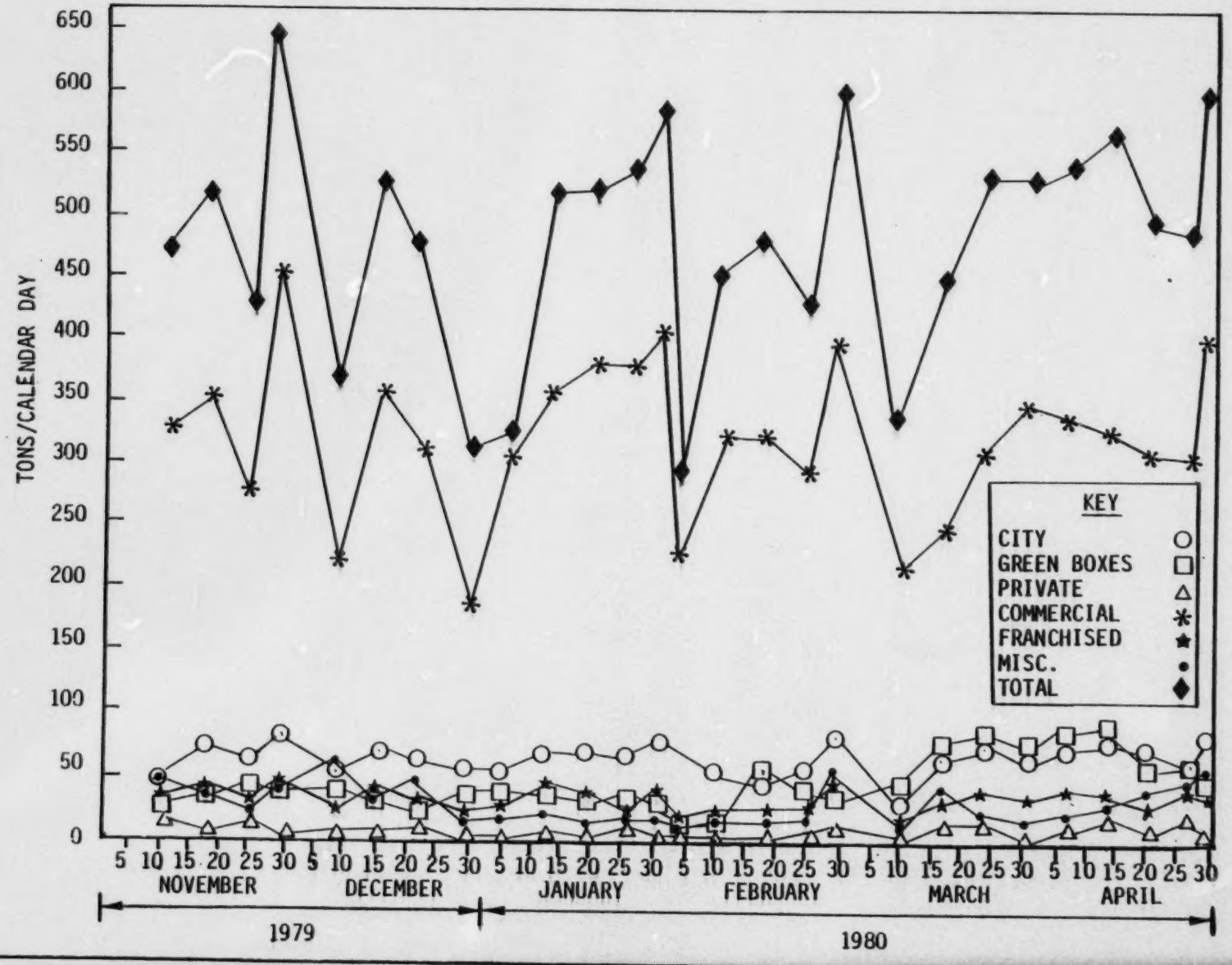

LEXINGTON COUNTY SOLID WASTE GENERATION
TONS/CALENDAR DAY
650
600
550
500
450
400
350
300
250
200
150
100
50
0
KEY
CITY
GREEN BOXES
PRIVATE
COMMERCIAL
FRANCHISED
MISC.
TOTAL
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
1979
1980

FIGURE 2.

CHAPTER 3
EXISTING DISPOSAL SYSTEM

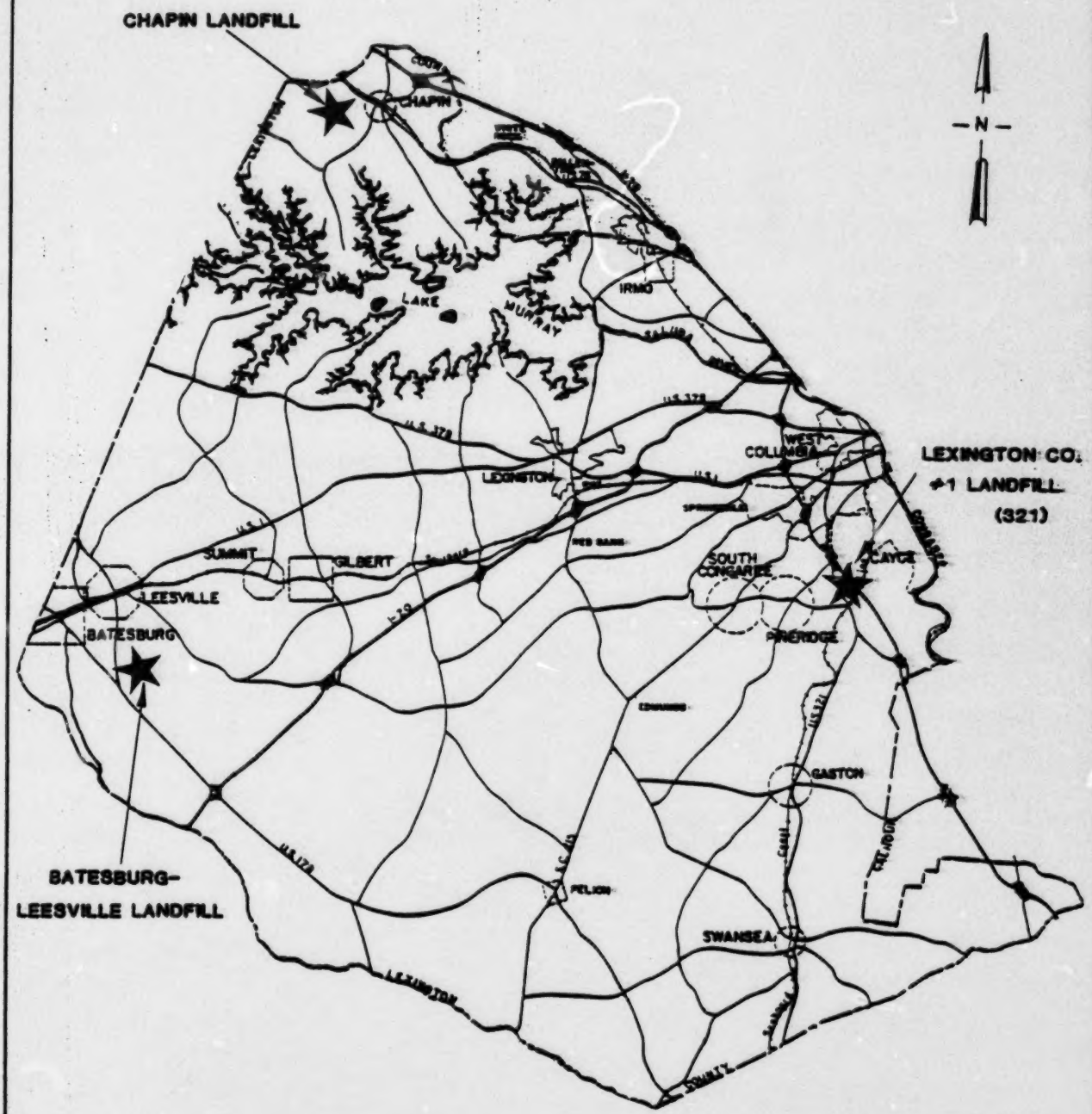
As stated previously, Lexington County currently operates three landfills within the county. The approximate location of each landfill is shown on the county base map, Figure 3.1.

Lexington County #1 landfill, the largest of the three county landfills, is located on the east side of U.S. Highway 321 approximately 1 mile south of the interchange of Interstate I-26 and U.S. 321. This landfill provides solid waste disposal for the cities of Cayce, West Columbia, Lexington, Springdale, and Swansea, as well as the majority of the unincorporated areas of the county (total estimated service area population of 127,000 from a total estimated county population of 139,000).

The county also operates two small landfills in less populated, remote areas of the county. The Chapin landfill, comprising 13 acres, is located approximately 1 mile northwest of Chapin on U.S. 76. This landfill serves the northernmost area of the county north of Lake Murray (population approximately 3,000). The Batesburg-Leesville landfill is located approximately 1 mile south of the Leesville city limits on U.S. 245. This landfill serves the towns of Batesburg and Leesville (combined population approximately 9,000). While these smaller landfills are a part of the overall solid waste disposal system in Lexington County, combined they only serve some 8.5 percent of the estimated total county population. For this reason the remainder of this chapter focuses on the main Lexington County landfill located in Cayce, or the Lexington County #1 landfill.

LEXINGTON COUNTY, SOUTH CAROLINA

EXISTING DISPOSAL SITES



Reproduced from best available copy.

LANDFILL DESCRIPTION

The Lexington County #1 landfill, subsequently referred to as the landfill, is located on a 132-acre tract of land, approximately 91 acres of which are leased by the county from the cities of Cayce and West Columbia, and another 41 acres are leased from a private citizen. A sketch of the property boundary is shown in Figure 3.2. Figure 3.3 shows that portion of the approximately 132-acre area owned by the two cities (which purchased the land jointly in 1971). The landfill is located in an abandoned sand mine that was converted into a landfill in May 1972. The landfill is permitted by the SCDHEC (Permit Number DWP030) as a sanitary landfill. On the basis of visual observation; discussions with landfill personnel, the county engineer, and SCDHEC personnel; and a review of previous studies, it was estimated that 30 to 40 of the total of 132 acres have been filled (see Figure 3.4).

Site Characteristics

Lexington County is in the approximate center of South Carolina. The northern one-fourth of the county is in the Piedmont Plateau, and the southern three-fourths are in the part of the Atlantic Coastal Plain known as the "Sandhills." The two physiographic provinces join along a line called the "Fall Line." In Lexington County, this line trends easterly across the county and is roughly parallel to and just north of U.S. Highway 1. The Piedmont Plateau is north of this line, and the Sandhills are south of it. The landfill is located in the Sandhills region.

Within the Sandhills Province are four geologic formations of unconsolidated marine deposits: the Tuscaloosa, Barnwell Sand, McBean, and Sunderland Terrace. The Tuscaloosa formation is the most extensive. The landfill is in the outcrop of the Tuscaloosa formation (also known as the Middendorf formation), which consists of light-colored sand and lenses of kaolin clay. Most of the formation underlies the Lakeland-Blaney Soil Association. This association consists of nearly level to strongly sloping, deep, excessively drained soils. Permeability is rapid in these soils, and available water capacity is low. (For a detailed discussion of the geology and physiography of the region, see references 3 and 13.)

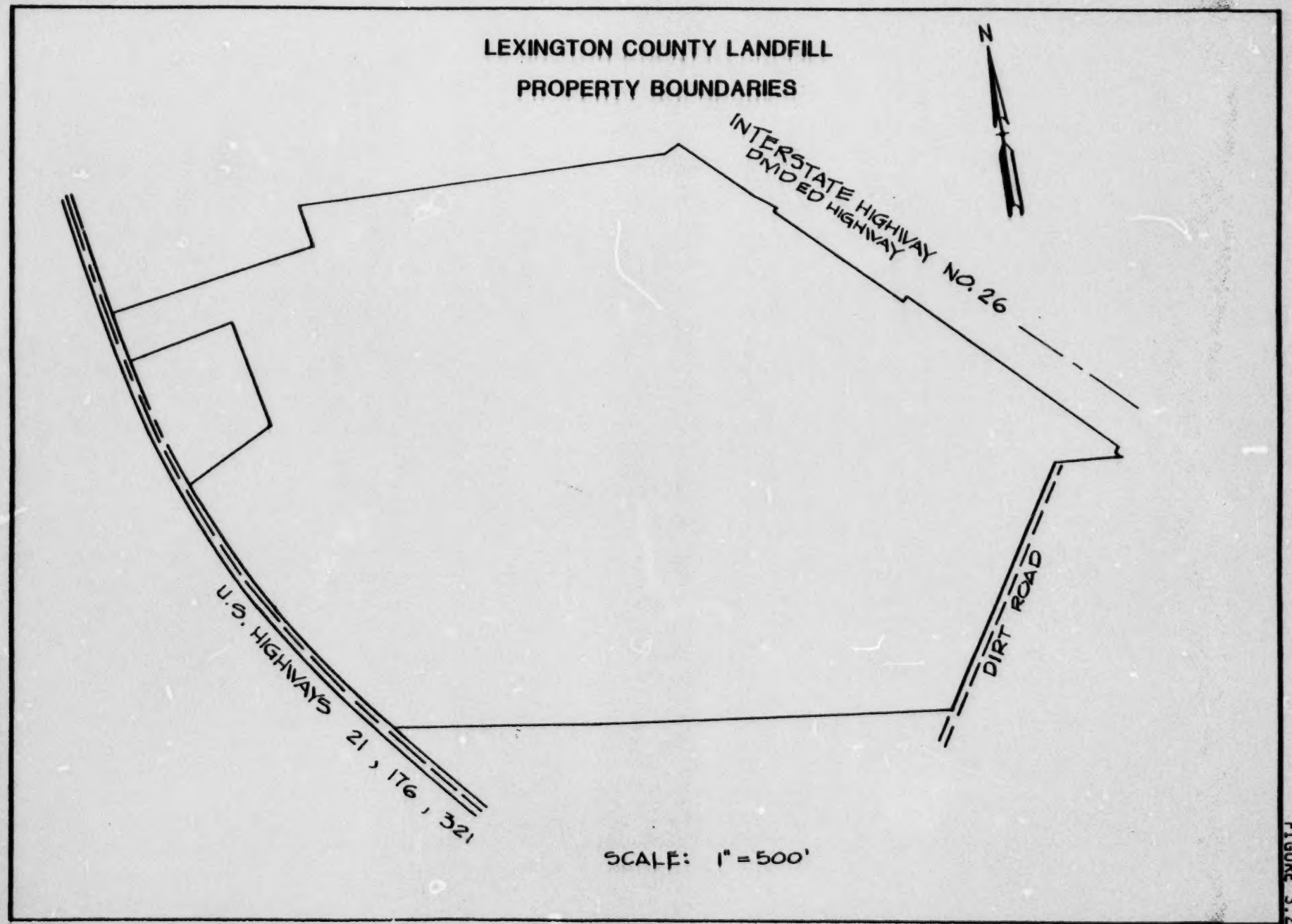
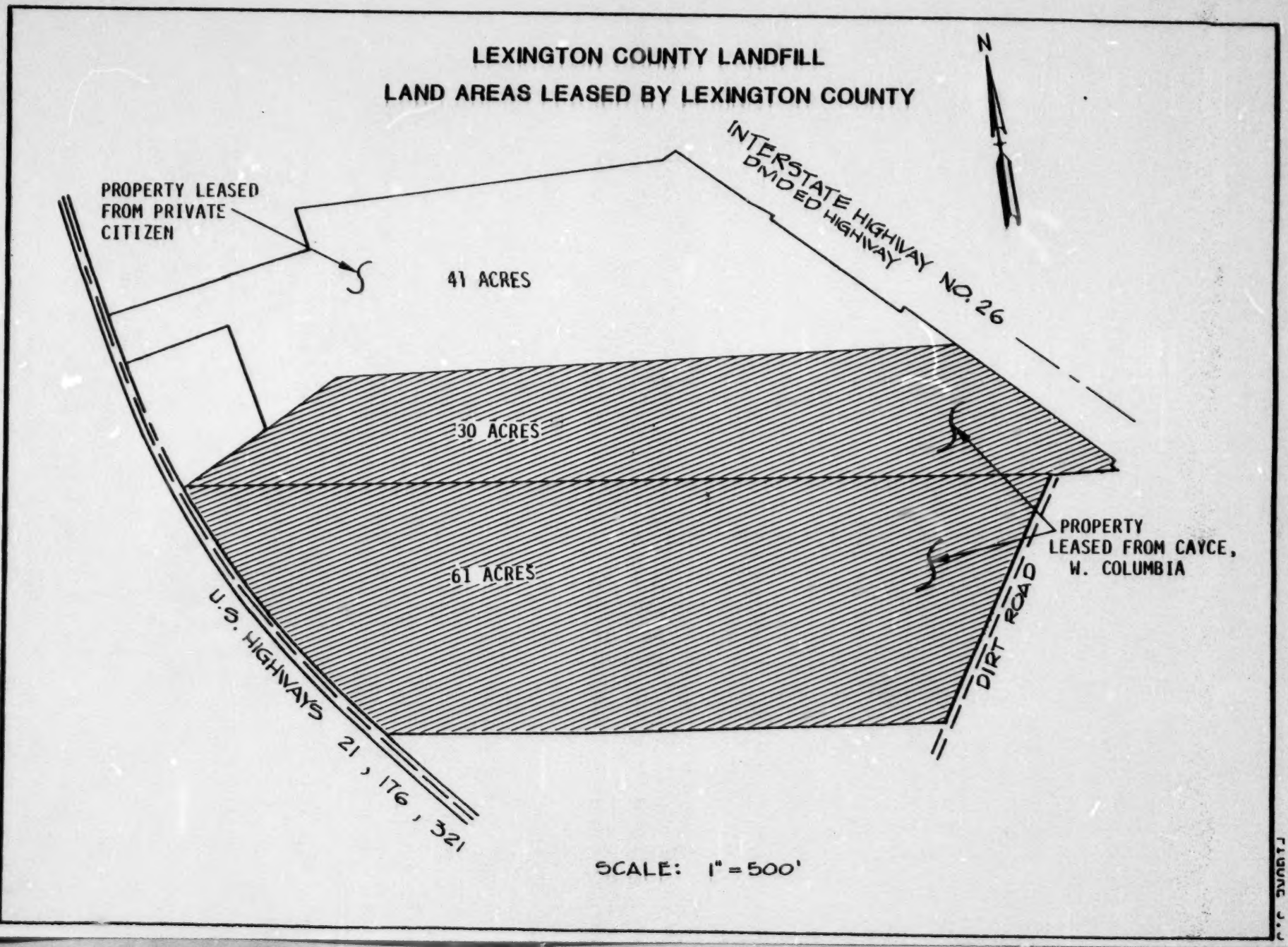

LEXINGTON COUNTY LANDFILL
PROPERTY BOUNDARIES
N
INTERSTATE HIGHWAY NO. 26
DIVIDED HIGHWAY
U.S. HIGHWAYS 21, 176, 321
DIRT ROAD
SCALE: 1" = 500'

FIGURE 3.1


LEXINGTON COUNTY LANDFILL
LAND AREAS LEASED BY LEXINGTON COUNTY
N
INTERSTATE HIGHWAY NO. 26
DIVIDED HIGHWAY
PROPERTY LEASED FROM PRIVATE CITIZEN
41 ACRES
30 ACRES
61 ACRES
PROPERTY LEASED FROM CAYCE, W. COLUMBIA
DIRT ROAD
U.S. HIGHWAYS 21, 176, 321
SCALE: 1" = 500'

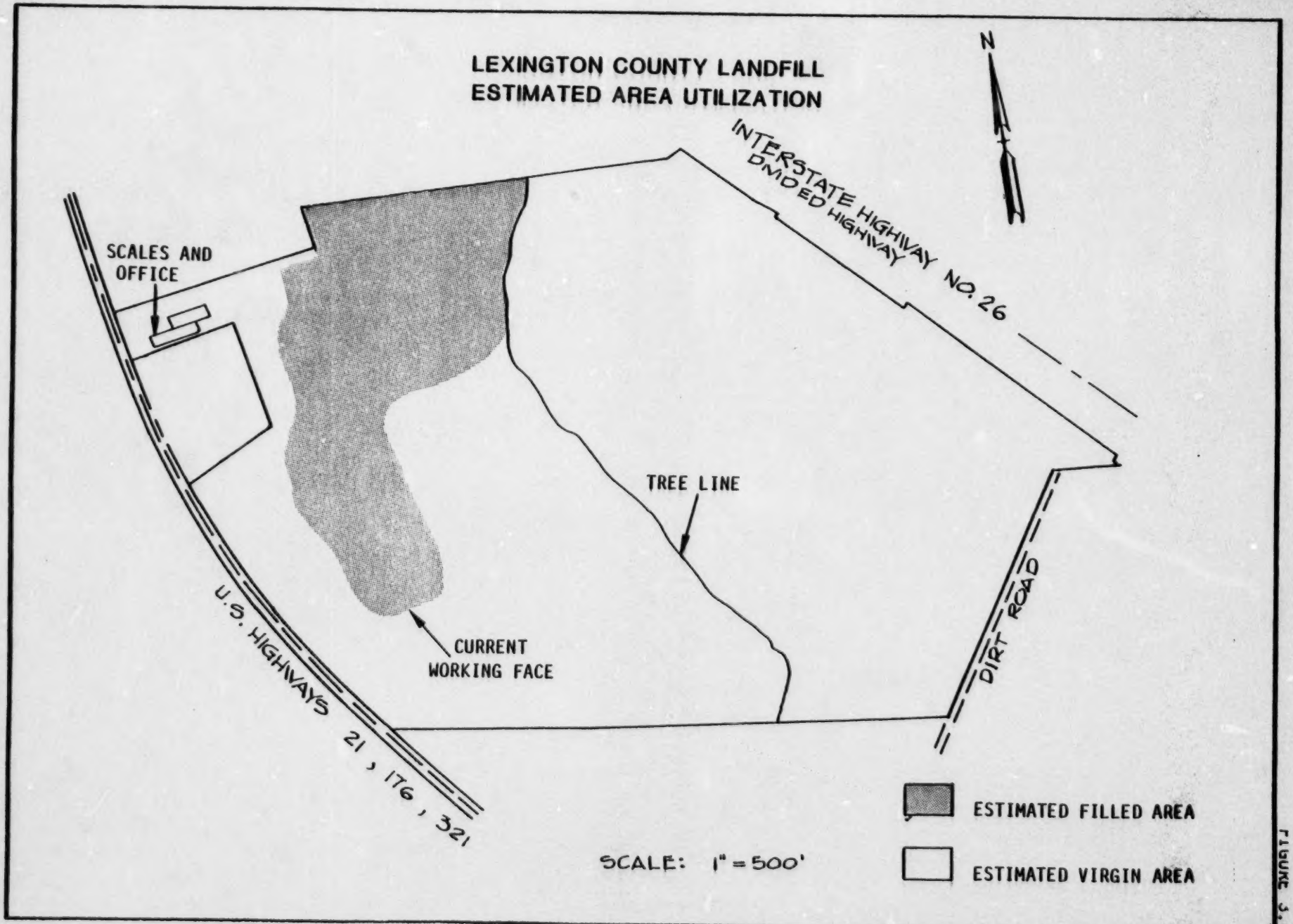

LEXINGTON COUNTY LANDFILL
ESTIMATED AREA UTILIZATION
N
INTERSTATE HIGHWAY NO. 26
DIVIDED HIGHWAY
SCALES AND
OFFICE
TREE LINE
DIRT ROAD
U.S. HIGHWAYS 21, 176, 321
CURRENT
WORKING FACE
ESTIMATED FILLED AREA
ESTIMATED VIRGIN AREA
SCALE: 1" = 500'

FIGURE 3.4

A study of the soils and geologic conditions of an area in which a new sanitary landfill is to be located is essential to understanding how its construction and operation affect the surrounding environment. A study should be conducted during the siting phase prior to the development of a landfill. During such a study, the limitations that the soils, geologic, and hydrologic conditions impose on the environmentally safe and efficient design and operation of a sanitary landfill should be identified. Such a preliminary engineering study was not conducted prior to the selection and development of the Lexington County landfill.

Three hydrogeologic investigations were subsequently conducted at the landfill[1]. All of these studies found potential and existing surface and groundwater pollution problems associated with the operation of the sanitary landfill. The major site-related problems identified in these studies are:

- Highly permeable sands used as cover material allowing unrestricted infiltration of rainwater increasing leachate generation and seepage.
- Rapid percolation of leachate through the highly permeable sand materials.
- Contamination of surface and groundwater.
- Potential for lateral migration of leachate and landfill gases.

---

[1]One was performed in 1975 by J. Michel entitled Groundwater Pollution and Geochemical Variations in Leachate from Solid Waste Disposal. Two investigations were conducted under previous EPA contracts. One was performed in 1975 and is entitled Evaluation of the Effect of the Lexington County, South Carolina Landfill on Ground and Surface Water. The other was conducted for EPA by the SCDHEC Hydrology Division and is entitled Evaluation of the Impact of Landfill Leachate on Groundwater Quality at the Lexington County, South Carolina Landfill Site. This study was conducted from September 1977 through January 1979.

These reports made recommendations that, if implemented, would potentially minimize pollution from the landfill site. These recommendations have not been implemented to date.

On the basis of discussions with the SCDHEC Solid Waste Division, it is highly probable that a detailed engineering study, including detailed site plans, an operating plan, and a closure plan, will be required of Lexington County in order for it to continue operations at this site. It should be pointed out that this technical assistance report in no way represents the engineering site development report that is likely to be required by the state.

General Operating Method

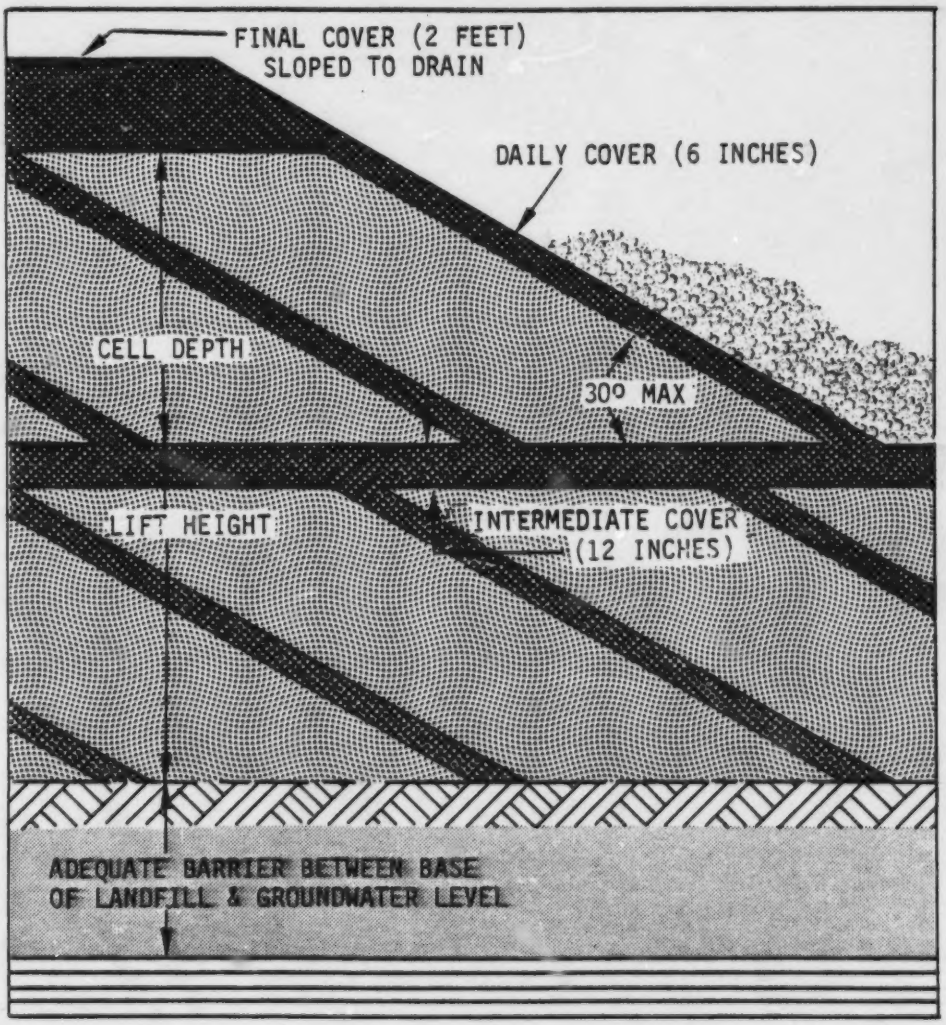
There are basically two landfilling methods, trench and area fill. The landfill was originally permitted in 1971 as a trench method sanitary landfill. However, because of the noncohesive properties of the sand, trench walls could not be maintained and the landfilling method was changed to the area method. Given the physical conditions and amount and types of solid waste to be handled, the switch to the area method appears to be justified.

On flat or gently rolling terrain where the groundwater is low and the soil is more than 6 feet deep, the trench method is recommended. This method is employed at both the Chapin and Batesburg-Leesville landfills. The area method, on the other hand, can be used on most topographies, especially when large quantities of waste are disposed of at the site. The building block common to both methods is the cell. All of the solid waste is spread and compacted in layers within a confined area. At the end of each working day, the waste is covered completely with a thin, continuous layer of soil which is also compacted. The compacted waste and soil cover are defined as a cell. A series of adjoining cells make up a lift. A typical cell structure is shown in Figure 3.5.

Cell dimensions are generally determined by the volume of the compacted waste and the density of the in-place waste. The field density of most compacted waste within the cell should be at least 800 pounds per cubic yard. If the land and cover material are readily available, a cell should have a minimum height of 8 eight. Heights up to 30 feet have been used in large operations. The key consideration for

FIGURE 3.5

TYPICAL LANDFILL CELL CONSTRUCTION



Ref: 6

the designer and operator is to keep the cover material volume at a minimum while disposing of as much waste as possible.

The cell should generally be square, with sides sloped as steep as operation will permit. The slope should be about 30 degrees to keep the cover material volume at a minimum. This angle will also provide good compaction of waste, particularly when spread in layers about two feet thick. A narrow working face should be maintained. It should be wide enough to allow unhindered waste dumping operations but should not exceed 150 feet. A typical schematic of the area method is shown in Figure 3.6.

Operating Procedures

The landfill operates 5.5 days a week: Monday through Friday, 7:00 a.m. - 4:30 p.m., and Saturday, 7:00 a.m. - 12:30 p.m. The hours of operation and other pertinent information are posted at the entrance to the landfill. The entrance to the site is controlled by fencing and a gateman/scale operator is on duty during normal operating hours.

The incoming waste is weighed using a 50-ton, above-ground Martin Decker scale. The scales were installed in October 1979 and weigh records have been maintained since November of that year. Prior to the installation of scales, waste volumes and weights were estimated. Fees are levied on a per-ton basis according to the schedule presented in Table 3.1; at the two smaller landfills, fees are levied on the basis of an estimated volume.

The efficiency of the landfilling operation depends on the smooth flow and unloading of trucks. The trucks are directed to the exact landfill area location in use by the gateman. Waste is dumped at the top of the working face and pushed and compacted downwards. The waste is spread in layers and is compacted by steel-wheeled compaction vehicles that make several passes over the waste. Cover material is brought from the area designated on Figure 3.7 by a scraper. The cover material consists of sand cut from the embankment on the eastern side of the currently cleared landfill area. The state of South Carolina Solid Waste Regulations require "a daily cover with a minimum of 6 inches of soil after compaction." The main functions of the

TYPICAL REPRESENTATION OF AREA METHOD

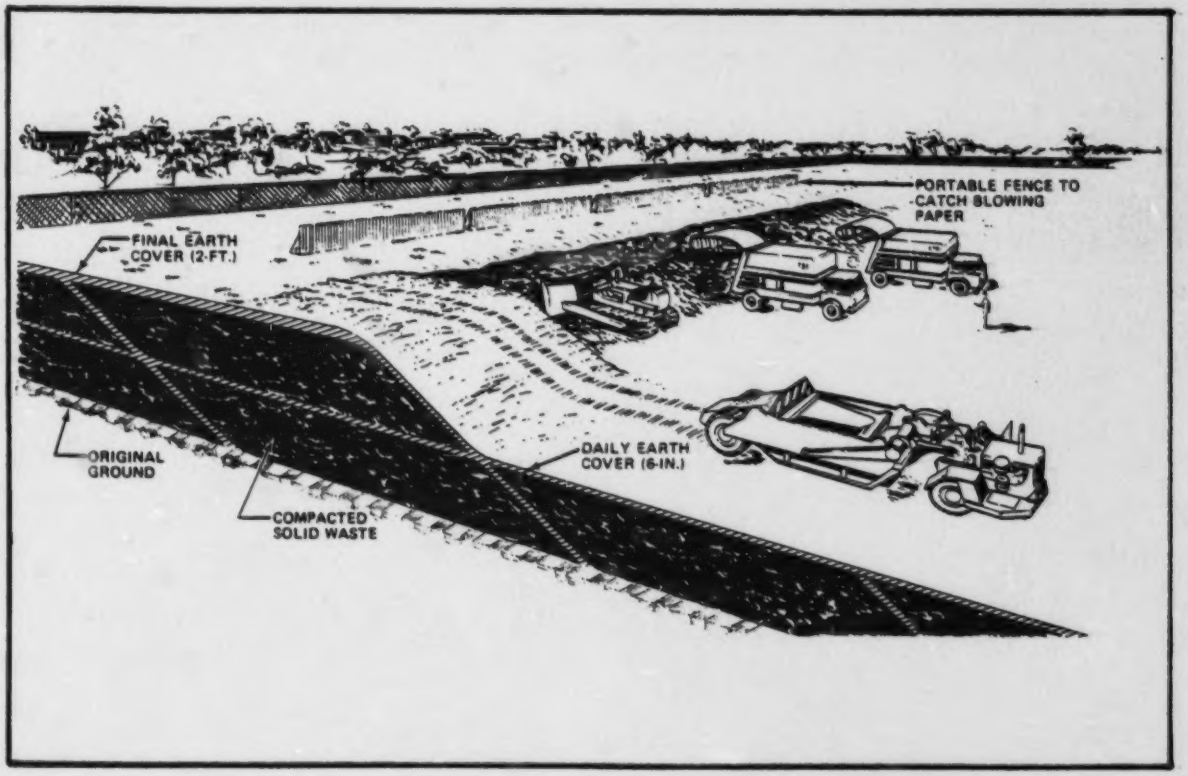


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TABLE 3.1

FEE SCHEDULE

Solid Waste Quantity	Tipping Fee
1. Lexington County #1	
Commercial	$ 3.75/ton
Franchise	$ 1.50/ton
Cities	$ 0.00
2. Chapin and Batesburg(1)	
0 yd^3 thru 4 yd^3 - Loose Garbage	$ 3.75
5 yd^3 thru 9 yd^3 - Loose Garbage	$ 7.50
10 yd^3 thru 19 yd^3 - Loose Garbage	$ 18.75
20 yd^3 thru 29 yd^3 - Loose Garbage	$ 22.50
30 yd^3 thru 40 yd^3 - Loose Garbage	$ 30.00
1 yd^3 thru 19 yd^3 - Packed Garbage	$ 22.50
20 yd^3 thru 29 C.Y. - Packed Garbage	$ 26.25
30 yd^3 thru 40 C.Y. - Packed Garbage	$ 33.75

(1) No scales; volumes are estimated.

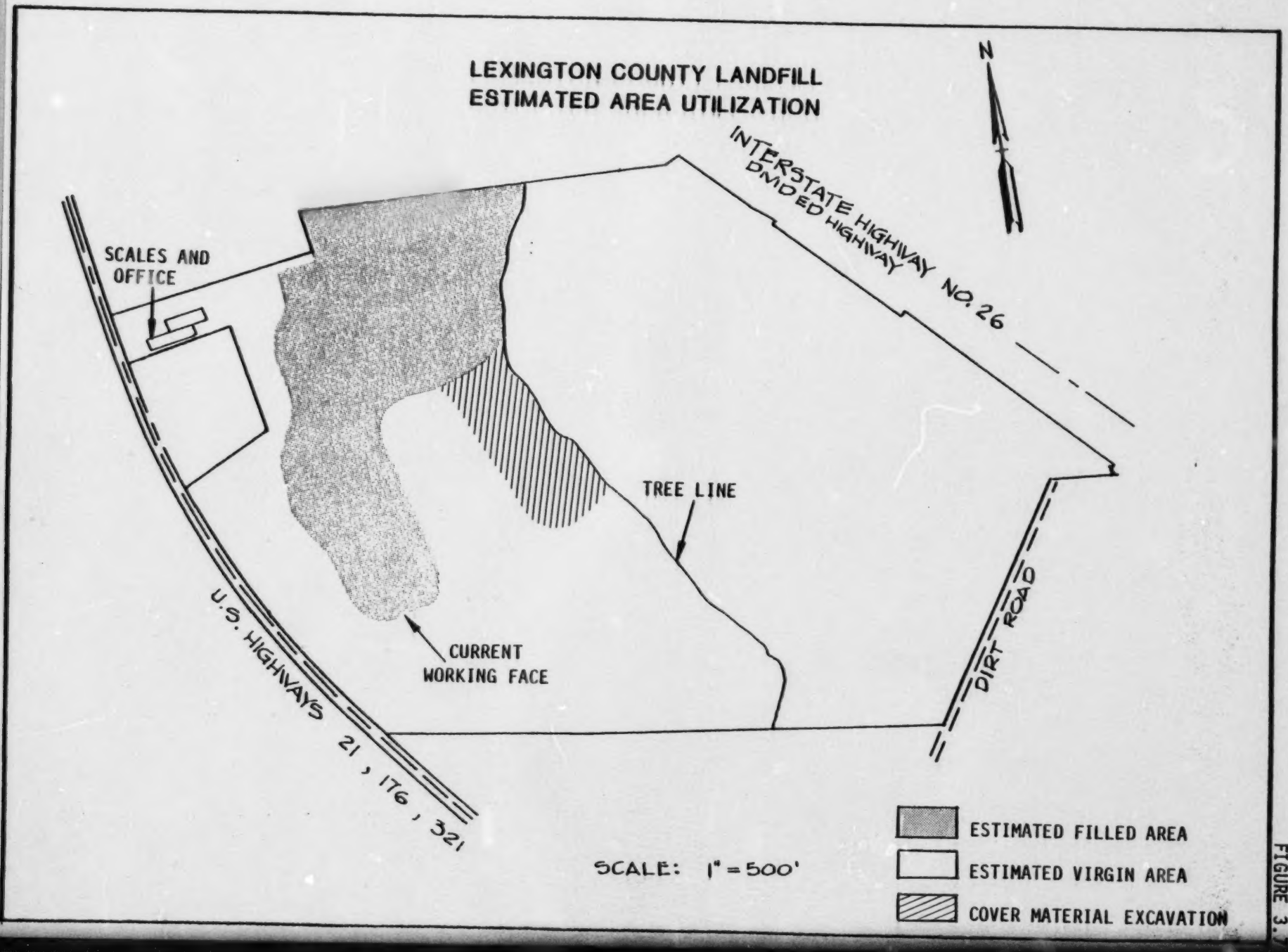

LEXINGTON COUNTY LANDFILL
ESTIMATED AREA UTILIZATION
N
INTERSTATE HIGHWAY NO. 26
DIVIDED HIGHWAY
SCALES AND
OFFICE
TREE LINE
CURRENT
WORKING FACE
U.S. HIGHWAYS 21, 176, 321
DIRT ROAD
SCALE: 1" = 500'
ESTIMATED FILLED AREA
ESTIMATED VIRGIN AREA
COVER MATERIAL EXCAVATION

FIGURE 3.7

Daily cover are to control vectors, litter, fire, and moisture. "Intermediate cover of not less than 1 foot compacted thickness is required on areas where the surface will be exposed more than 30 days. Final cover of not less than 2 feet is required for any surface that represents the final grade of the landfill or that will not receive more fill within one year."

Landfill Equipment

Currently, four pieces of heavy equipment are used on a regular basis for working the landfill:

- One tracked crawler front end loader (Caterpillar 977)
- Two steel wheeled compactors (Caterpillar 816)
- One 23 cubic-yard elevating scraper (Clark 210HB).

Table 3.2 summarizes pertinent information on this equipment.

While crawler machines can only operate at a maximum speed of 8 mph they have good flotation and traction capabilities and are excellent for excavation. A crawler (unlike a dozer) is capable of lifting materials off the ground and can carry soil as far as 300 feet.

The compactors are equipped with large trash blades. The power train is similar to that of rubber-tired machines. Their major asset is their steel wheels, which are very effective in crushing and compacting. Compactors work well for spreading and compacting on flat surfaces and on moderate slopes. Their maximum speed is 23 mph.

The scraper is used to excavate, haul, and spread cover material.

On the basis of performance characteristics of typical landfill equipment (presented in Table 3.3), the existing equipment appears to be adequate for the landfill.

PROBLEMS IDENTIFIED AT EXISTING LANDFILL

Based upon visual observations made at the site, discussions with SCDHEC personnel, and a review of landfill inspection forms, several problem areas were identified at the landfill site. These problems should be addressed, and provisions for correction implemented by Lexington County in order to assure compliance with existing environmental

TABLE 3.2

LEXINGTON COUNTY #1 LANDFILL EQUIPMENT

Item Type	Manufacturer	Model Number	Purchase Date	Estimated Total Life* (years)	Flywheel Horsepower (HP)	Operating Weight (lbs)	Estimated Operating Cost* ($/hr)	Other
Front-end Loader (Track)	Caterpillar	977L	1976	5 - 6	190	47,000	$12.50	
Elevating Scraper	Clark	210HB	1979	5 - 6	324	--	$24.70	23 yd^3 capacity
Compactor (Steel-Wheeled)	Caterpillar	816	1978	5 - 6	170	40,000	$ 9.75	
Compactor (Steel-Wheeled)	Caterpillar	816	unknown	5 - 6	170	40,000	$ 9.75	

*Ref: Rental Rate Blue Book for Construction Equipment 1979. Published by Equipment Guide-Book Co., Palo Alto, CA.

TABLE 3.3

PERFORMANCE CHARACTERISTICS OF

LANDFILL EQUIPMENT

Equipment	Solid Waste		Cover Material			
	Spreading	Compacting	Excavating	Spreading	Compacting	Hauling
Crawler dozer	E	G	E	E	G	NA
Crawler loader	G	G	E	G	G	NA
Rubber-tired dozer	E	G	F	G	G	NA
Rubber-tired loader	G	G	F	G	G	NA
Landfill compactor	E	E	P	G	E	NA
Scraper	NA	NA	G	E	NA	E
Dragline	NA	NA	E	F	NA	NA

E = Excellent G = Good F = Fair P = Poor NA = Not applicable
*Basis of evaluation: Easily workable soil and cover material haul distance greater than 1,000 feet.

REF: 9

regulations for operation of sanitary landfills. These problem areas are pointed out in order that Lexington County can take corrective action and not jeopardize future permitted disposal at this site. Identified problems are:

- Failure to submit an engineering report or detailed plans to SCDHEC as required under Section R.61-70, III, B of the South Carolina Statutes and Regulations.
- Inadequate leachate control (contamination of surface and ground water by leachate from the landfill is documented in references already mentioned in this chapter). Existing site geological conditions and current operating methods are not suitable to prevent further contamination. Every state inspection conducted during the past year has sited the facility with leachate control violations. Standing water was observed in two low areas of the landfill during site visits. Visible leachate seepage out of fill was also observed.
- Other problems sited by the state during inspections over the past year, including:
  - Dust
  - Blowing litter
  - Stabilization
  - Exposed waste
  - Surface erosion
  - Odor
  - Inadequate daily and interim cover.
- Disposal of unacceptable waste. Toxic materials and hazardous wastes must be excluded from the sanitary landfill. Other special wastes (e.g., approved sludge, hospital waste, animal carcasses,) must be properly handled. During site visits, exposed hospital waste was observed (e.g. syringes, tubing, medicine containers, gloves, masks, intravenous bags).
  In the past, materials such as pesticides, sulfuric acid, phos-

phoric acid, caprolactam, asbestos, titanium dioxide, sewage treatment sludges, ink sludges, paint wastes, lithium polystyrene sulfinate, and other industrial wastes have been disposed of in the landfill. Due to siting, design, and operating methods at this site, the disposal of these materials constitutes a potential threat to the environment and should be discontinued.

- After-hour scavenging.

Most of the above problems can be alleviated or minimized through revised operating procedures and development of acceptable cover and closure procedures.

POTENTIAL USE OF SITE AFTER CLOSURE

The landfill site was purchased by the cities of Cayce and West Columbia in 1971 with a Department of Housing and Urban Development (HUD) "Grant for Development of Open Space." The HUD grant provided 50 percent of the land purchase price. The future use of the landfill is restricted by the grant contract under Section 2 (b) as follows:

"The Public Body agrees to retain said land, as developed, for permanent open space purposes, and the open space use or uses of said land shall be for park and recreational purposes, conservation of land and other natural resources, or historic or scenic purposes."

Planning Considerations

As stressed throughout this report, engineering planning must include planns for an ultimate end use and must be an on-going activity at a sanitary landfill. Because of problems inherent in completed landfills, such as settling, low weight carrying capacity, corrosiveness of the waste, methane gas generation and restricted excavation, final land use must be fully evaluated and properly planned and engineered. Given these problems, most landfill sites are designed for an end use as a green area or recreational area, rather than a site on which buildings are constructed. When landfills are used for construction purposes, allowances must be made to deal with the unique factors involved.

If plans call for structures to be built on or near a completed landfill, a foundations engineering expert should be consulted. The costs associated with design, construction, and maintenance of structures on or near landfills are considerably higher than they are for those erected on well compacted earth fill or on undisturbed soil.

Light, one-story buildings are sometimes constructed on the landfill surface. The bearing capacity of the landfill should be determined by field investigations in order to design continuous foundations. Foundations should be reinforced to bridge any gaps that may occur because of differential settlement in the fill. Roads, parking lots, sidewalks, and other paved areas should be constructed of a flexible, easily repairable material, such as gravel or asphaltic concrete. Very little information is available on the load bearing capacity of landfills, but existing data suggest that completed landfills have a load bearing capacity of about 500 - 800 pounds per square foot.

Landfill gases continue to be produced after the landfill is completed. These gases can accumulate in structures or soil, cause explosions, and kill vegetation. Design of gas controls should conform with the planned use of the completed fill. Gas control techniques include lining the outside of the foundation with an impermeable liner to prevent gas from entering or collecting under structures, as well as gas-venting provisions and equipment.

Land Uses

If proper planning occurs and the inherent problems are addressed, there are many ways in which a completed landfill can be used. As stated previously, the end use of the Lexington County landfill is restricted to recreational or open land uses by the HUD grant, consequently, only these uses will be discussed.

The use of a completed landfill as a green area is very common. No expensive structures are required, and a grassed, landscaped area is developed for the pleasure of the community. Some maintenance work is, however, required to keep the fill surface from becoming eroded by wind and water. The cover material should be graded to prevent water

from ponding and infiltrating the fill. Gas and water mo
stations, installed during construction, should be period
led until the landfill stabilizes. Gas and water control
also require periodic inspection and maintenance.

Proper landscaping of the site is important both dur
operations as well as for the end use of the site. Atten
be given to soil type, plant hardiness, and effective pla
satisfying the goals and objectives of the proposed end u

Many landfills have been used for such recreational
ski slopes, coasting hills, ball fields, golf courses, pa
preserves, amphitheaters, playgrounds, jogging paths, bik
hiking trails. Small, light buildings, such as concessio
sanitary facilities, and equipment storage sheds, are usu
at recreational areas. These should also be constructed
tlement and gas problems at a minimum. Other problems e
ponding, cracking, and erosion of cover material. Period
includes regrading, reseeding, and replenishing the cove

Landfills have been successfully used for everythin
space to New York's LaGuardia Airport, the Los Angeles B
the Milwaukee County baseball and football stadium, and
ramp of the soapbox derby in Virginia Beach, Virginia.
for various end uses are presented in Tables 3.4 and 3.5

TABLE 3.4

DESIGN CRITERIA FOR OUTDOOR PLAY ACTIVITIES

STANDARDS FOR RECREATIONAL ACTIVITIES

Types of Recreation Activity	Space Requirements for Activity Per Population	Ideal Size of Space Required for Activity	Recreational Area Wherein Activity May be Located
A. Standards for Recreational Activities			
Active Recreation			
1. Children's Play Area (with equipment)	0.5 acre/1,000 pop.	1 acre	Playgrounds-Neighborhood Parks, Community Parks, School Playgrounds
2. Field Play Areas for Young Children	1.5 acres/1,000 pop.	3 acres	Playgrounds-Neighborhood Parks, Community Parks
3. Older Children-Adult Field Sports Activities	1.5 acres/1,000 pop.	15 acres	Playfield-Community Park District Park
4. Tennis-Outdoor Basketball Other Court Sports	1.0 acres/5,000 pop.	2 acres	Playfield-Community Park
5. Swimming	1 outdoor pool/25,000	Competition size + wading pool - 2 acres	Playfield-Community Park
6. Major Boating Activities	100 acres/50,000	100 acres and over	District Park-Regional Park or Reservation
7. Hiking-Camping-Horseback Riding-Nature Study	10 acres/1,000 pop.	500-1,000 acres	Large District Park-Regional Park
8. Golfing	1-18 hole course per 50,000 pop.	120 acres	Community Park-District Park
Passive Recreation			
1. Picnicking	4 acres/1,000 pop.	varies	All parks
2. Passive Water Sports Fishing-Rowing-Canoeing	1 lake or lagoon per 25,000 pop.	20 acre water area	Community Park Special Regional Reservations
3. Zoos, Arboretums, Botanical Gardens	1 acre/1,000 pop.	100 acres	Large District Park or Special Facility
Other			
1. Parking at Recreational Areas	1 acre/1,000 pop.	varies	Playfields, Community, District & Regional Parks
2. Indoor Recreation Centers	1 acre/10,000 pop.	1-2 acres	Community Parks
3. Outdoor Theaters, Band Shells	1 acre/25,000 pop.	5 acres	District Parks

Type of Area	Acres Per 1000 Population	Size of Site Ideal	Size of Site Minimum	Radius of Area Served
B. Standards for Recreation Areas				
Playgrounds	1.5	4 acres	2 acres	0.5 miles
Neighborhood Parks	2.0	10	5	0.5
Playfields	1.5	15	10	1.5
Community Parks	3.5	100	40	2.0
District Parks	2.0	200	100	3.0
Regional Parks and Reservations	15.0	500-1,000	varies	10.0

Source: George Nez, "Standards for New Urban Development - The Denver Background." Urban Land, Vol. 20, No. 5, Urban Land Institute, N.W. Washington, D. C.

TABLE 3.5

DESIGN CRITERIA FOR GOLF COURSES

	Minimum Area Required	Maximum Area Required	Number of Parking Spaces	Population Served	Service Radius	Average Length
9-hole course	60 acres	80 acres	100 cars	1 hole per 3,000 persons or 27,000 persons	1/2-3/4 hour by car or public transportation	Approx. 2250 yards
18-hole course	120 acres	160 acres	200 cars	1 hole per 1,500 persons or 25,000 persons	1 hour max. by car or public transportation	6500 yards

REF: 8

CHAPTER 4
ALTERNATIVE MEANS OF EXTENDING LANDFILL LIFE

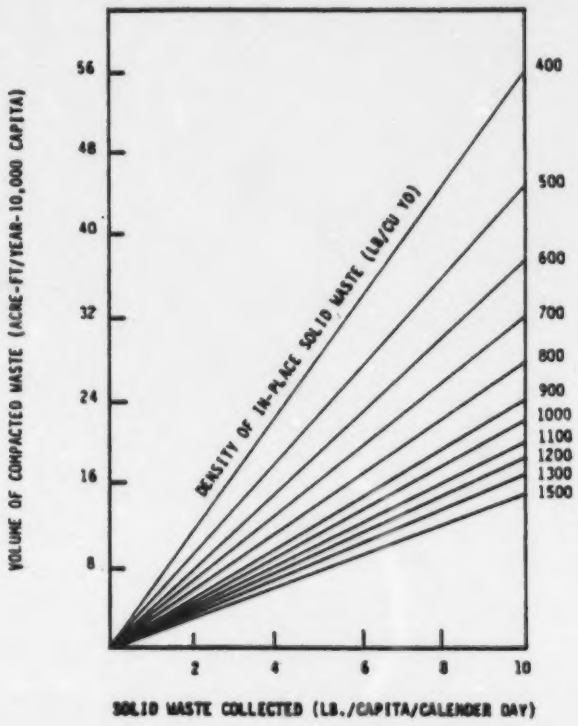
In this chapter, the remaining useful life of the Lexington County landfill is estimated. Then, means of extending that life, exclusive of resource recovery, are assessed. Chapter 6 addresses resource recovery possibilities.

The remaining usable landfill area at the Lexington County Landfill is limited. The remaining capacity required is primarily dependent upon the character and quantity of the solid wastes, the efficiency of compaction of the wastes, the depth of the fill, and any physical constraints associated with the site.

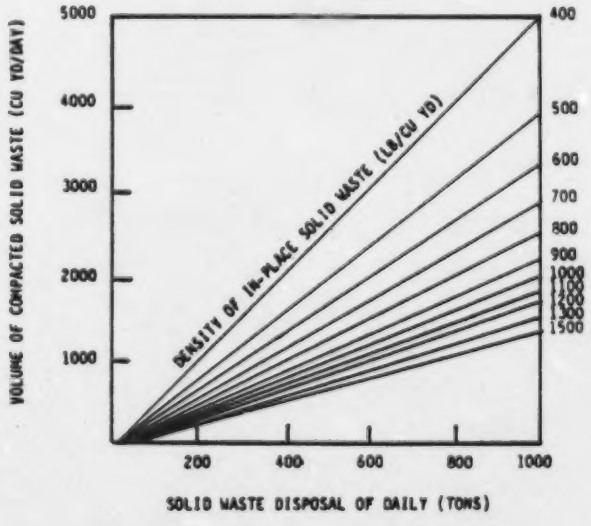
If the daily volume of solid waste collected and the capacity of the landfill site are known, the useful life can then be estimated. The ratio of solid waste to cover material volume usually ranges between 4:1 and 3:1. The thickness of the cover and the cell configuration influence the ratio. If the cover material is not excavated from the fill site, this ratio may be compared with the volume of compacted soil/waste and the capacity of a site determined. Figure 4.1 (A) can be used, for example, to determine the acre-feet per year used by a population of 10,000, for various compaction densities and the daily rate of solid waste collected. Based on the total tonnage to be disposed of at a proposed sanitary landfill, the daily volume of compacted solid waste can be determined from Figure 4.1 (B).

Field density or solid waste density at landfills is the weight of a unit of volume of solid waste in place. A well compacted landfill will have a field density of 800 to 1,000 pounds per cubic yard. Landfill density is the weight of a unit of volume of in-place solid waste divided by the volume of solid waste and its cover material.

LANDFILL VOLUME REQUIREMENTS



(A) YEARLY VOLUME OF COMPACTED SOLID WASTE GENERATED BY COMMUNITY OF 10,000



Ref: 9.

(B) DAILY VOLUME OF COMPACTED SOLID WASTE GENERATED BY LARGE COMMUNITIES

The remaining usable life of the Lexington County landfill can be estimated based upon the following assumptions:

- Field density of 800 pounds per cubic yard
- Solid waste collected - 8 lbs/capita/day
- Remaining virgin land - 80 acres
  (Total 130 acres - 40 used acres, 10 acres non-usable)
- Average landfill depth - 30 feet.

From Figure 4.1, the volume of compacted solid waste is 23 acre-ft/year-10,000 capita; or approximately 292 acre-ft/year (based on population of 127,000). Based upon the above assumptions, approximately 9.7 acres per year will be required. This translates to an estimated usable life of 8.2 years. A more conservative estimate allowing for population increases, however, might be 6 to 8 years.

During the course of this study, several means of extending the usable life of the Lexington County landfill have been identified. These methods can be categorized as follows:

- Solid waste volume reduction
- Increased area utilization efficiency resulting from adoption of systematic operating plan
- Increased area utilization resulting from alternative land-filling method
- Restriction of noncounty use of landfill.

The approaches are discussed individually in the following subsections.

SOLID WASTE VOLUME REDUCTION

There are essentially three basic methods for solid waste volume reduction. These three methods can be categorized as follows:

- Volume reduction through mechanical processing
- Volume reduction through reduced generation
- Volume reduction through increased resource recovery.

Mechanical Processing

Volume reduction through mechanical processing has been practiced in several different ways in this country. Processing systems have included

compaction at the source in stationary compactors in the home or in compactor trucks, compaction at central locations (i.e. transfer stations), as well as shredding, grinding, and baling systems.

Shredding

Shredding can significantly reduce the volume of wastes especially with bulky wastes. When compacted in a landfill, shredded waste density is 25 to 60 percent greater than unshredded, depending on whether daily cover is required. (Reference 12).

There are 11 basic types of size reduction equipment commercially available - crushers, cage disintegrators, shears, shredders, cutters and chippers, rasp mills, drum pulverizers, disk mills, wet pulpers, hammermills, and grinders. To date, wet pulpers, hammermills, and grinders have been used in the United States for the size reduction of municipal solid waste. Of these three equipment types, the hammermill is most commonly used in solid waste applications.

The size of the particles produced is quite important to the effectiveness of the step following shredding. The shredding system must be capable of meeting the particular size requirements. Hammermills have provisions for mechanical particle-size control. Other factors can also affect particle size, including wear of components within the shredder, the moisture content of the waste, number of hammers used within the shredder, the composition of the waste, and feed rate (tons per hour).

A large portion of the total solid waste load can be shredded. Some wastes, however, cannot be put through the mill because of size or density or because they are hazardous, have high moisture content, or have other qualities that normally call for special handling in any system.

Long-term experience in shredding solid waste is still lacking, but the major problems have been identified and significantly reduced. These problems usually center around the materials handling aspect of feeding the mill and subsequent removal of the shredded material. Jamming of the shredder and uneven feeding can significantly reduce the throughput of the mill, although this has generally been solved on a

local basis by simple improvisations. This uneven feeding can result in uneven hammer loading and wear, as well as surges in power. At the other end, unless the shredded material is rapidly removed from the mill, a backup jam may occur.

Cities with a severe shortage of landfill space and/or cover material might consider shredding if local conditions permit. Local regulatory authorities should be contacted to determine how present regulations would affect landfilling of shredded wastes. Other than cover requirements, all normal sanitary landfilling procedures must be followed in landfilling shredded waste; under certain conditions, consideration must be given to leachate collection and treatment.

Because shredding involves an additional processing step over landfilling, additional operating and capital costs are incurred. Ten shredding facilities were surveyed under EPA contract in 1975 to determine costs.

The annual operating costs and the annualized capital costs for the 10 shredder sites were updated to 1980 costs using ENR cost indexes. The sites had an average operating cost per ton of $8.36 and an average annualized capital cost per ton of $2.52, resulting in a total cost per ton of $10.88. The operating costs averaged 77 percent of total costs. All costs reflect the operation of the shredder facility itself and the transportation of the shredded waste to a landfill, but not costs of transporting to shredder nor cost of landfilling shredded material.

Baling

Baling is another method of reducing the volume of solid waste. It has the potential to achieve cost savings when transfer and long haul are necessary prior to disposal and when land disposal space is at a premium. It also has an added benefit in that baling makes the waste potentially easier to handle and transport. A decision to implement baling depends on how well baling and the operation of the bcxefill compete with nonbaling processes and conventional landfilling.

In other words, the comparison should be made on an economic and environmental basis for the particular community. The different forms of baling must be compared with each other as well.

There are, at present, three main types of solid waste balers: a multistage baler with no preprocessing; a horizontal, continuous push-through baler with preshredding; and a baler developed from that used for corrugated materials at supermarkets with no preprocessing.

Because of the relative newness of solid waste baling technology, firm cost figures are very difficult to establish. For two baling projects in which EPA has been involved, costs per ton were $9.50 and $13.70, respectively (costs were updated to August 1980 using ENR cost indexes). Projected economics available for other locations indicate costs ranging from $8.79 to $9.98 per ton (August 1980 costs).

Advantages of baling operations are:

- Baling nearly doubles the life of the land disposal site and therefore reduces the number of times the city government must go through the difficult process of acquiring a new disposal site. Densities vary from 1,000 to more than 1,700 pounds per cubic yard, depending on the type of baler used.
- Balers can handle most types of wastes.
- Bales are easier to handle and transport than unprocessed waste; they are therefore more convenient for operations such as rail hauling.
- Baling should permit more immediate use of the disposal site upon completion as minimal settling is anticipated.
- In shredding/baling operations, ferrous metal can be recovered for recycling via magnetic separation after shredding. Also corrugated containers and white goods can be handpicked and baled separately and sold.

Disadvantages include:

- Baling involves a greater initial investment than a conventional transfer station handling the same tonnage.
- Baling precludes resource recovery once the bale is formed.

- There is limited information about the economics of baling and the effects of baling on decomposition in landfills, gas and leachate formation, and settling.

Reduced Generation

Local government decision makers have generally been involved in the two traditional areas of solid waste management -- collection and disposal. As the cost and environmental concerns associated with disposal have increased, growing numbers of local governments have begun to include resource recovery within their solid waste management functions. While these three aspects solid waste management deal with waste once it has been generated, they do not deal with the primary cause of solid waste management problems -- the rapidly expanding quantity of waste being generated. In order to address this basic problem, a relatively new solid waste management concept called waste reduction, or source reduction, has evolved. The waste reduction concept involves policies that are designed to reduce the comsumption of materials and products in order to reduce the generation of solid wastes.

There are four means of reducing waste generation: product reuse, reduced material use in products, increased product lifetime, and decreased consumption of products.

The product reuse option is applicable to the broad and increasing category of consumer goods designed to be used once and thrown away. Reusable products could be substituted in many instances. A prime example of this option is the use of refillable beverage containers as a substitute for nonrefillable beverage containers.

The second option is to decrease the materials consumed in each product; for example, the elimination of excess packaging or the selection of smaller automobiles by consumers. This option could involve savings in energy as well as materials.

The increased product lifetime or durability option would involve the redesign of products for sturdier construction and/or improved ease of maintenance. In general, the option would apply to so-called durable goods such as automobiles, tires, appliances, and furniture.

The fourth option - decreased consumption - would mainly involve a reduction in the per-capita consumption of packaging or disposable products.

The implementation of any of these four waste reduction options would involve an alteration of the existing production and marketing structure of numerous companies, as well as a significant change in consumer habits. Since production and distribution systems are often national in scope, a local government is generally limited in its ability to implement a waste reduction program beyond its own procurement policies (e.g., the purchase of longer life radial tires for its vehicles).

The county or city government has virtually little or no control over waste generation reduction programs. These types of programs must be developed and implemented at the state and federal level. These possibilities are mentioned here simply to alert local officials of the possibility for becoming involved in the development of national programs of this type.

Resource Recovery

The recovery of energy or materials from solid waste can create many benefits for the community. Some benefits may be expressed in terms of dollars; others may not. The community may benefit from lower waste disposal costs, reduced volumes of solid waste to dispose of and therefore, longer landfill life. A detailed discussion of resource recovery is presented in a subsequent chapter of this report.

IMPLEMENTATION OF A SYSTEMATIC OPERATING PLAN

An area that has a high potential for extending the life of the landfill is improved operations and efficiency through the adoption and adherence to a systematic operating plan. While all the steps in the landfilling process are important, proper operation of a site should receive the most attention. A well operated site will cost less to operate, extend landfill life, optimize the use of manpower and equipment, and minimize maintenance problems. Moreover, after the landfill is completed, the area can be more easily turned into a community asset, such as a park or golf course.

The best designed disposal facility will be of little value unless it is constructed and operated as prescribed. This is especially true of a sanitary landfill because it is under construction up to the day the last ton of solid waste is disposed of. Constructing the sanitary landfill on a daily basis in accordance with the design should be required in an operations plan.

An operating plan is essentially the specification for construction and operation and it should describe all items required to construct the sanitary landfill. More specifically, it should describe: 1) hours of operation; 2) measuring procedures; 3) traffic flow and unloading procedures; 4) specific disposal areas and methods of handling and compacting various solid wastes; 5) placement of cover material; 6) maintenance procedures; 7) adverse weather operations; 8) fire control; 9) litter control; 10) salvaging operations, if permitted.

Proper operation calls for drawing up a comprehensive plan that spells out routine procedures and anticipates abnormal situations. It must also provide for continuity of activities even when personnel changes occur. New supervisors and personnel responsible for solid waste disposal must know what is being done at the landfill and why. The plan must, however, remain open for revision when necessary. Changes should be noted, and the rationale behind them explained. New personnel will benefit from the experience of others, and continuity of operations will be preserved.

The plan should also be used as a tool in training employees, defining their jobs, and giving them an insight into the work of others. In this manner, the employee will more fully understand the overall operation, and he may be able to perform other duties in an emergency.

While operating plans differ from site to site, the basic issues to be addressed are fairly standard. The items that should be addressed are outlined Table 4.1.

Improved operating efficiency translates into direct cost savings. On a dollar basis, operating expenses far outweigh initial design and other capital costs. In fact, the operating costs are often two to four times the annualized capital cost for a landfill facility.

TABLE 4.1

OUTLINE FOR TYPICAL OPERATION PLAN

I SCOPE
- A. Introduction
- B. Special provisions
- C. Site description
- D. Site development
- E. Site volume

II GENERAL LANDFILL INFORMATION
- A. Entrance area preparation
- B. Subgrade preparation
- C. Groundwater and leachate control
- D. Internal roadway system
- E. Detailed landfilling process
- F. Clay seal construction
- G. Monitoring system
- H. Operational controls
  1. Line and grade
  2. Earthmoving estimates
  3. Refuse weighing and classifying
  4. Adverse weather conditions
     - a. Wet weather
     - b. Cold weather
  5. Safety
     - a. Fire prevention
     - b. Odor control
     - c. Vector control
     - d. Salvaging
     - e. Accident prevention and safety
  6. Personnel

- I. Maintenance control
  1. Dust control
  2. Litter control
  3. Surface runoff handling
     - a. Drainage measures
     - b. Erosion controls
  4. Equipment

III SPECIFIC LANDFILL INFORMATION
- A. Entrance area preparation
- B. Bottom grades and leachate collection system
- C. Existing contours, grid control, sequencing and boring locations
- D. Detailed filling of sequences 1 and 2
- E. Filling of sequences 4, 5, and 6
- F. Abandonment and closure plan

IMPROVED LANDFILLING METHODS

Another area with excellent potential for extending landfill life is the application of improved landfilling methods. Landfilling methods generally refer to several aspects of landfilling procedure. Three basic aspects are:

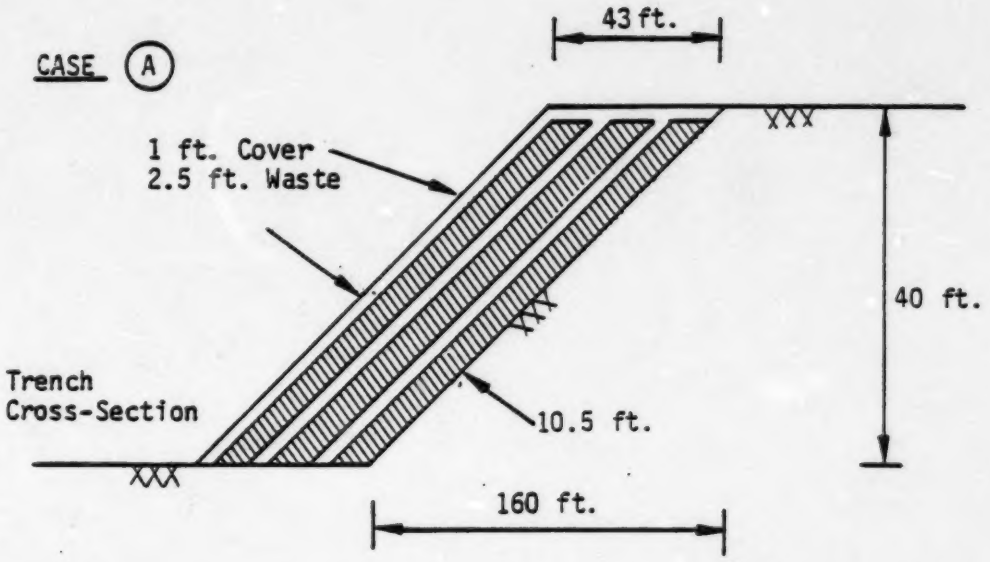
- Placement of the cell with respect to the natural grade of the land.
- Placement of the cell with respect to adjacent cells.
- Physical shape and structure of the cell.

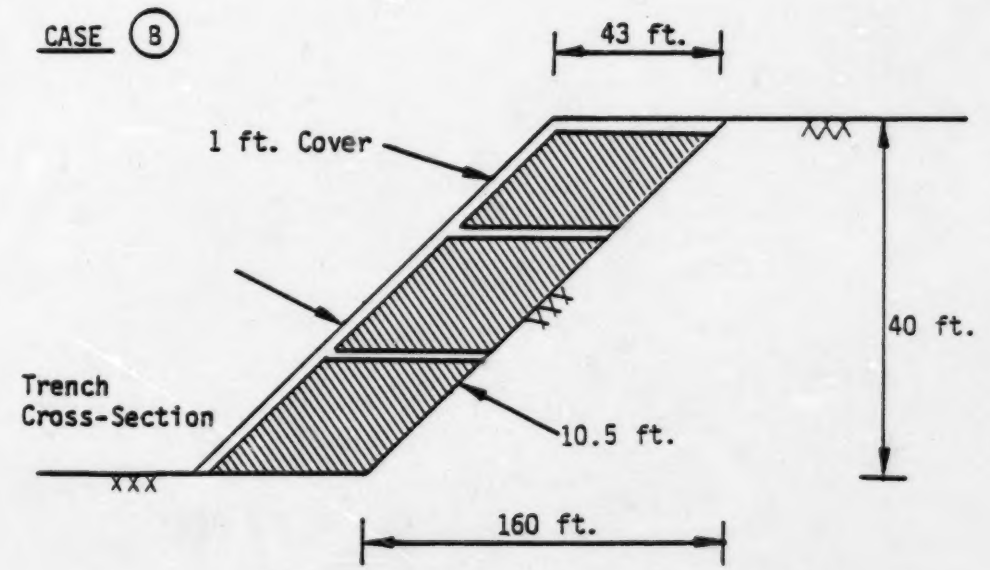
The basic refuse cell structure can have a significant impact upon landfill volume utilization efficiency (and thus area utilization efficiency). An increase in volume utilization efficiency can be achieved if the volume of daily cover required per unit volume of in-place refuse can be reduced.

An illustrative example using a 40 feet deep fill is shown in Figure 4.2. The two sketches show cross sections of the working face. In both cases, equal amounts of landfill volume have been consumed (about 64 cubic yard/foot working face length) and 1 foot of daily cover has been provided. However, the cells in Case B have been structured differently than those in Case A. The cells in Case B are more compact and require less cover per unit volume of refuse. In Case B, about 53 cubic yards of compacted waste have been filled per foot of working face length, while only about 44 cubic yard per foot have been disposed of in Case A. This represents an increase in landfill volume utilization efficiency of about 14%.

The method which is presently employed at the Lexington County landfill results in a fill which extends to approximately 40 feet below natural grade with final cover placed at or near natural grade. One concept that could be used to increase area utilization efficiency (i.e., increase the volume of waste landfilled per acre) is to increase the total thickness of the waste layer. This could be applied to the current method by increasing the depth of the fill and/or increasing the final elevation of the fill. The usable life of the Lexington County landfill could be extended by increasing the top elevation of the fill.

EXAMPLE ILLUSTRATING HOW CELL STRUCTURE CAN AFFECT VOLUME UTILIZATION





Note: Sketches not to scale.
Dimensions are as noted.

County personnel have expressed a desire to make the landfill aesthetically attractive and compatible with the surrounding land area after final closure. This goal can be achieved even if the final ground surface is higher in places than the original ground surface, providing proper consideration has been given to:

- Major surface water drainage paths
- Erosion protection
- Landfill structural stability
- Final land use.

The volume and area utilization efficiency of a landfill can be increased if the quantity of soil required to provide adequate daily cover can be reduced. Usually, landfills can be operated such that 6 inches of daily cover is provided and about 20% of the landfill's volume is occupied by cover soil (4 parts refuse to 1 part cover). Normally, about 6 inches is required to prevent blowing litter and keep vermin from entering the refuse. It is not easy to apply a uniform 6-inch soil cover to compacted refuse and it requires care and skill on the equipment operator's part. There are certain things which can be done to make it easier to apply a uniform cover layer that is not excessively thick. One procedure which can help is to form the cell and compact the refuse before applying the cover soil; it is difficult to apply a uniform layer of cover to loose refuse. It is also helpful to maintain moderate working slopes.

Compacting solid wastes is an important feature of proper landfill operation, essential to the conservation of landfill space and the construction of cells with a minimum of litter, aesthetic covering and settling problems. The compaction of solid wastes is influenced strongly by its unique characteristics. Wastes are very heterogeneous; waste types within each vary greatly, and the waste from any load can be quite different from the waste of another load. The potential for compaction of waste is great, and success depends on the proper use of equipment.

To improve compaction, it is necessary to understand the mechanism of compaction. One of the principal factors of compaction is the compression due to the weight of the compaction equipment. A steel-wheeled

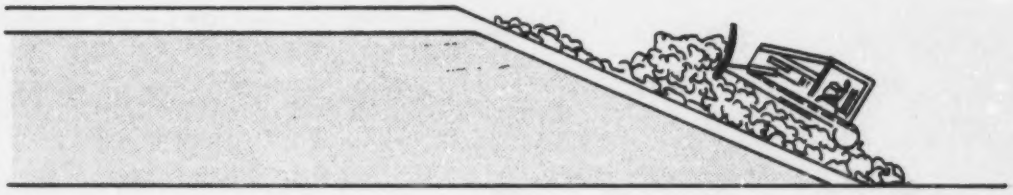
compactor, like those used at the Lexington County landfill, weighs from 40,000 to 60,000 pounds. Assuming that the total surface area of the wheels in contact with the refuse is 25 square feet for a vehicle with a weight of 60,000 pounds, the average surface pressure is 2,400 pounds per square foot. However, deeper into the refuse, the weight of the vehicle is distributed over a larger area, reducing the pressure below that experienced at the surface. This decrease in compaction pressure with depth means that, for most efficient compaction, the layer of refuse being compacted should be as thin as possible.

The graph presented in Figure 4.3 shows the relationship between the thickness of the layer of refuse and the density of compacted wastes produced during a field test of a particular type of machine and operating procedure. Note the rapid decrease in density after a thickness of about 1.5 feet. For most efficient refuse compaction, the refuse should be compacted in a number of thin layers up to the total cell thickness. The number of passes that the machine should make over the wastes to achieve optimum compaction depends on a number of factors, including machine wheel pressure; wastes compactability; land, fuel, and labor costs; and work load. The second graph presented in Figure 4.3 shows the relationship between waste density and number of passes. Usually, two to five passes will achieve the best utilization of compaction effort. At several landfill locations, it has been found that spreading and compaction can be improved if the waste is dumped at the toe of the working face and spread and compacted upwards against the slope. This method is presented in Figure 4.4.

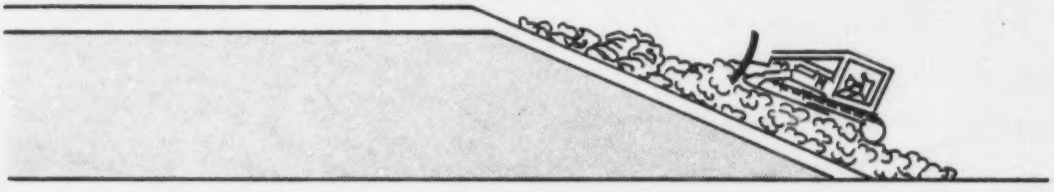
Tires are a bulky material that are difficult to landfill. During the site visit, it was observed that tires were a problem at the Lexington County landfill. If placed in the landfill cell along with other refuse, they will invariably work themselves to the surface as a compactive effort is applied by the landfill equipment. There are, however, several methods which can be used to landfill tires.

ALTERNATE METHOD OF SPREADING AND COMPACTION

STEP 1



STEP 2



STEP 3

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STEP 1: UNLOAD SOLID WASTE AT TOE OF SLOPE

STEP 2: SPREAD IN THIN LAYERS (APPROXIMATELY 2 FEET)

STEP 3: COMPACT BY RUNNING TRACTOR OVER WASTE LAYER 2 TO 5 TIMES

A variety of tire shredders are available commercially. These machines shred tires into small pieces of rubber. Once tires have been shredded, they can easily be landfilled along with other refuse. The purchase and operation of tire shredders can be costly. Normally their use is feasible only in locations where a relatively large quantity of tires must be disposed.

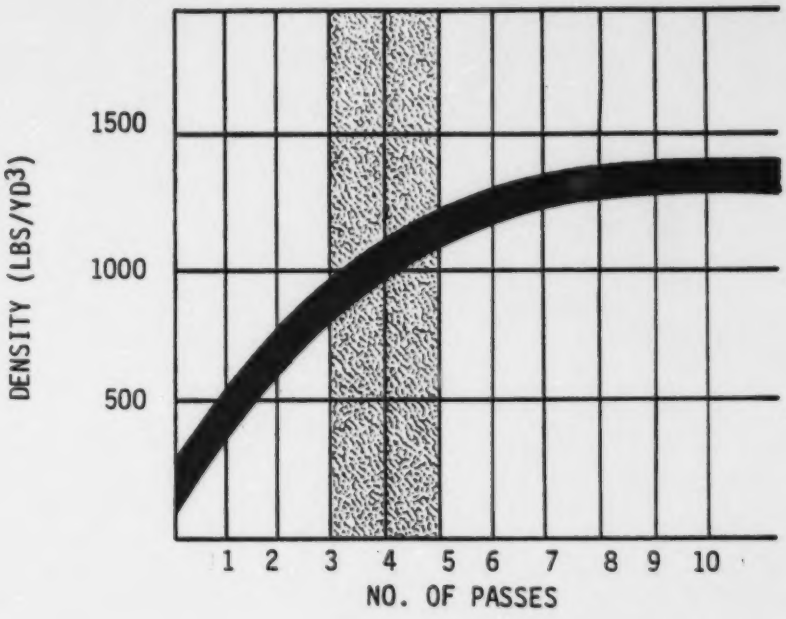
There is another method for landfilling tires that is simple and relatively inexpensive -- the pit method. This method involves placing the tires in a separate pit and covering them with soil. To achieve economic benefits, it is necessary to place the tires in a location where it will not be necessary to make several trips over them for compaction purposes. A tire pit can be located apart from the refuse landfill area or can be placed in the buried refuse just below final cover. The pit method is simple has been used successfully at a number of operating landfills. The pit method appears to be extremely practical for application at the Lexington County landfill.

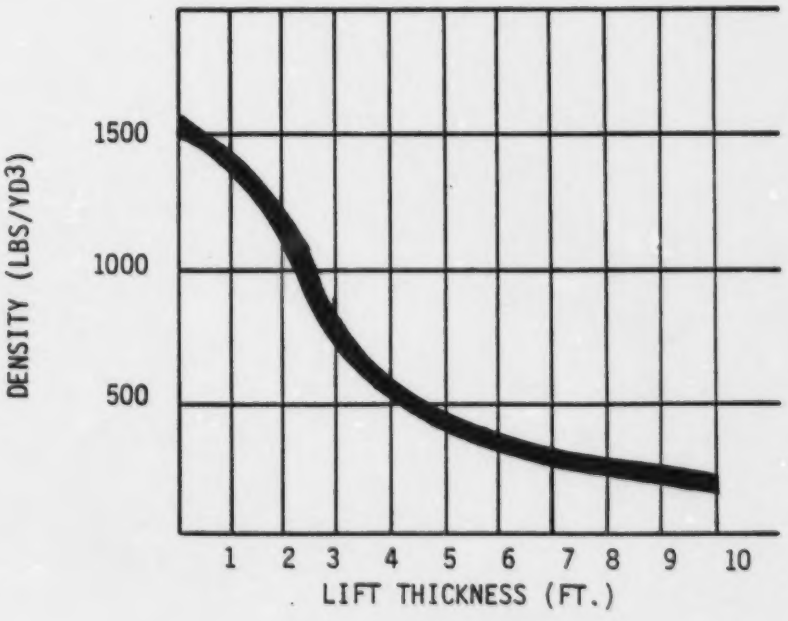
A feasibility study by the South Carolina Marine and Wildlife Resources Department for statewide tire disposal is in progress. The concept of disposal is to bind the tires together and deposit them off the shore of South Carolina to create an artificial reef. It is believed that small aquatic organisms (e.g., coral) will affix themselves and cover the tires with calcareous material. A reef like this could become a site for feeding by larger aquatic life forms. The concept not only provides disposal of tires but also creates a site for an aquatic community and, possibly, a good fishing location. It is not known what the costs would be for participating in such a program. There will be costs associated with transport of the tires to a central collection point and perhaps a disposal fee.

RESTRICTED NONCOUNTY USAGE OF LANDFILL

During the site visit, the Lexington County engineer noted that a large amount of waste from Richland County is disposed of in the Lexington County landfill. The southern part of Richland County is geographically closer to the Lexington County landfill than to the

LANDFILL COMPACTION RELATIONSHIPS





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Richland County landfill. Richland County constructed a transfer station south of Columbia to service this southern area. Much of this county's waste still goes to the Lexington County landfill because a tip fee of $5.85/ton is charged at the transfer station and only $3.75 is charged at the Lexington County landfill. It is anticipated that this problem will be intensified, as a bridge is being built across the river from Richland County to Lexington County within 1 mile of the landfill.

Lexington County should evaluate various methods for restricting landfill usage by noncounty entities. These methods might include restriction by ordinance, increased tipping fee, or a dual tipping fee.

SUMMARY

A variety of concepts have been presented which have potential for increasing the usable life of the Lexington County Landfill. Table 4.2 summarizes the options that have been discussed and indicates the relative estimated potential for success of each.

TABLE 4.2

SUMMARY OF CONCEPTS FOR EXTENDING USABLE

LIFE OF LEXINGTON COUNTY LANDFILL

Concept	Potential for Success[1]			Further Study Required
	Good	Moderate	Poor	
1. Solid Waste Volume Reduction				
o Mechanical Processing		X		X
o Reduced Generation			X	
o Increased Resource Recovery		X		X
2. Adoption of Systematic Operating Plan	X			
3. Alternate Landfilling Methodology	X			
4. Restriction of Noncounty Usage		X		X

(1) Refers to technical potential for extending present landfill service life. Economic comparisons with alternate disposal options have not been done.

CHAPTER 5
FUTURE WASTE DISPOSAL ALTERNATIVES FOR LEXINGTON COUNTY

As described previously, the cities of Cayce and West Columbia and Lexington County dispose of commercial, residential, and landscape waste at a landfill which is located in Cayce, South Carolina. It is estimated that the landfill will be exhausted in 6 to 8 years using the current landfilling method. Even if more efficient landfilling techniques were adopted and other actions were taken (see Chapter 4), it is doubtful that the property could be used for landfilling for more than 10 to 12 years. It is safe to say that, within the next 4 to 10 years, Lexington County will require an alternative method or site for disposal of its municipal waste. The objective of this chapter is to present and discuss waste disposal options which will be available to Lexington County in the future.

DISPOSAL METHODS

Currently three basic methods are commonly used for municipal refuse disposal:

- Sanitary landfilling
- Incineration
- Composting.

The most commonly used method is sanitary landfilling.

Incineration has been used since the late 1800s for the disposal of municipal refuse and is especially attractive in situations where landfilling space is limited. However, incineration is not an ultimate disposal technique; landfill space is still required for ash and unburnable residue disposal. Incineration facilities require

relatively large initial capital expenditure and incur rather high operation and maintenance costs. Normally, in a location where adequate landfill space is available, incineration is not the most economically attractive refuse disposal option.

Composting has not been successfully used as a method for municipal waste disposal and resource recovery in the United States. The practice of composting has two basic positive effects:

- A net reduction in waste mass occurs due to biological degradation
- The finished compost has a value as a soil conditioner.

Composting of combined municipal solid waste has been more successful in Europe and Asia than it has in the United States because:

- European and Asian waste normally has a much lower cellulose content due to a lower percentage of paper and thus produces a compost with higher nutrient value.
- The demand for compost as a soil conditioner has been higher in Europe and Asia than it has been in the United States.

Composting results in a net reduction in solid waste volume and can be used strictly as a means for reducing the quantity of solid waste which must be landfilled. However, the landfill cost savings usually do not offset the cost of the composting process. In general, it can be said that, under current conditions, a market for the finished compost must be available to make composting an economically attractive method for municipal solid waste disposal.

At present, landfilling is the most economically attractive method of refuse disposal in most situations where landfill space is available. It is likely that landfilling will be the most practical and inexpensive refuse disposal option for Lexington County in the coming years. When the present landfill is exhausted the County will have two landfill alternatives:

- To establish a new landfill site
- To dispose of municipal refuse in a landfill which is operated by some other entity.

The following sections of this chapter discuss the feasibility of these two options. The concept and economics of large scale solid waste transfer will also be presented since this technique could have an impact upon future solid waste management decisions.

ESTABLISHMENT OF A NEW CITY LANDFILL

One potential solution to the future problem of solid waste disposal for Lexington County is to establish a new landfill. The disposal of solid wastes into or on the land surface is regulated by both state and federal regulations. The prime objectives of these regulations are: the protection of the public health and environment, the development and implementation of the solid waste management plans, and the development of resource conservation and recovery programs. The major regulations which will impact upon the disposal of solid waste within the State of South Carolina are summarized in the following section of this chapter.

Landfill Regulations

RCRA provides for the development of federal and state programs to regulate land disposal of waste materials and for the development of resource recovery programs. The Act was promulgated to regulate the generation, transportation, treatment and disposal of all solid wastes; to phase out the use of open dumps for disposal of solid wastes; and to promote the conservation of natural resources through the management, reuse or recovery of solid and hazardous waste.

Proposed Guidelines for Landfill Disposal of Solid Wastes were issued under Section 1008 of the Solid Waste Disposal Act, as amended by the RCRA (Federal Register, March 26, 1979). The Proposed Guidelines describe recommended considerations and practices for the location, design, construction, operation, and maintenance of solid waste landfill disposal facilities. The purpose of the Proposed Guidelines is to publish "suggested guidelines" that "provide a technical and economic description of the level of performance that can be attained by various available solid waste management practices (including operation practices)

which provide for the protection of public health and the environment." A brief summary of the Proposed Guidelines follows:

1. Site Selection (Section 241.200) - This section emphasizes that the selection of a site for the landfill disposal of solid waste should be accomplished in consideration of the areal ground and surface water conditions; geological and topographical features; social, geographic and economic factors; and environmental impacts. This section suggests avoidance of environmentally sensitive areas (wetlands, floodplains, critical habitats of endangered species, permafrost areas and recharge zones of sole source aquifers). Zones of active faults and karst terrain are areas that should also be avoided.
2. Design (Section 241.201) - This section of the Guidelines consists of a discussion of the various topics which should be addressed during the design stage of landfill development. It emphasizes the value of a clear presentation of all design features in appropriate plans to facilitate review by the appropriate regulatory authority, as well as to facilitate operation in accordance with the original design.
3. Leachate Control (Section 241.202) - This section of the Guidelines addresses the potential for adverse impact on ground and surface water by landfill disposal of solid waste. This section recommends the application of techniques to achieve containment of the solid waste through placement of very low permeability materials on the bottom and sides of a landfill (liner) and sealing of the surface of the completed landfill (cap). The guidelines suggest diversion of surface runoff away from or around the landfill (diversion structure design to divert the ten-year 24-hour precipitation event). Liner material permeability requirements (1×10^{-7} cm/sec) and minimum thickness (one foot) are specified.

4. Subsequent sections of the Guidelines address the recommended methods for Gas Control (Section 241.203), Runoff Control (Section 241.204), Landfill Operation (Section 241.205) and Monitoring (Section 241.206).

In addition to the Proposed Guidelines, EPA issued Criteria for Classification of Solid Waste Disposal Facilities and Practices under Section 4004 and 1008 of the Act (Federal Register, September 13, 1979). These Criteria establish performance standards (based on environmental protection which a land disposal facility must achieve to avoid designation as an "open dump." The Criteria were proposed to regulate the impact of a landfill on:

1. environmentally sensitive areas;
2. surface water;
3. groundwater;
4. air;
5. land use for the production of food-chain crops;
6. disease vectors; and
7. various other safety hazards, including explosive, toxic or asphyxiating gases, fires and bird hazard to aircraft.

Landfill Siting and Design

The primary components of a landfilling operation are the site itself, the equipment used, the personnel required to operate and monitor the site, and the site structures. Sufficient personnel and equipment are required for hauling, waste handling, earth moving, placement and compaction, and monitoring. The site structures should provide shelter and sanitary facilities for the operating personnel and storage for the equipment.

The landfill site should be located within a reasonable hauling distance of the waste production centroid. In general, a site with sufficient distance above the groundwater table, out of the floodplain and with soils of low permeability are most desirable. Prior to selection of a landfill site, detailed geologic and hydrogeologic information should be obtained. Typical information to be collected includes:

- Soil Borings (complete logs) - depth to bedrock
  - -lithology and hydrologic characteristics of bedrock formation
  - -name, age, and structural characteristics of the formations encountered during the boring operation and/or which crop out on or adjacent to the site
  - -depth and elevation of the water level in the borehole
  - -soil textural classification
  - -particle size distribution of soil samples
  - -coefficient of permeability of soil samples
  - -ion-exchange capacity and ability to absorb and "fix" heavy metal ions.
- Hydrologic Information
  - -groundwater table level and fluctuation
  - -vertical and horizontal components of the hydraulic gradients
  - -an analysis of the background groundwater quality
  - -surface drainage patterns

The hydrogeology of the site will determine its ultimate suitability and greatly influence the final design of the the facility. Not only is it extremely important to determine the effect of the the hydrogeologic regimen on the landfill operation, it is equally important to predict the effect of the landfill operation on the hydrogeologic regimen.

In addition to hydrogeologic data, other information must be collected and evaluated during the preliminary site investigation program, including:

- Surrounding land use patterns
- Location of structures, roads, and utilities
- Property line survey and evaluation of easements or right-of-ways
- Evaluation of potential problems such as leachate and gas generation
- Site access and traffic patterns
- Evaluation of final land use
- Evaluation of zoning restrictions.

As a general rule, it is usually desirable from a technical and

economic viewpoint to dispose of the solid waste at a point nearest to where it is generated, but it is recognized that this is not always possible. The approximate centroid of solid waste generation is presented in Figure 5.1 (the centroid was taken from the Lexington County Solid Waste Management Plan, 1978). The facility should be located as close to the centroid area as possible. If no acceptable sites in this area are available, it may be necessary to select a remote location. The remote site has both advantages and disadvantages that must be considered on a case by case basis. The major disadvantage to a remote location is that the waste material must be hauled from the point where it is generated to the point where it must be disposed, increasing disposal costs. An advantage of using a remote site is that topography and geology of the area can be selected to handle a landfill operation. If a remote location is selected, a transfer facility should be investigated. Solid waste transfer systems (combination of transfer facility and transfer vehicle) are often used to reduce the costs of hauling refuse. Refuse collection vehicles transport the solid waste to a central facility where it is unloaded either directly or indirectly onto a transfer vehicle that will carry it to the ultimate disposal site. Transfer vehicles can transport solid waste at a lower per-ton cost than refuse collection vehicles. A solid waste transfer operation becomes economically attractive when the costs of the transfer station plus the costs to transport the waste to the disposal site via a transfer vehicle are less than the costs to transport the refuse directly from route with the collection vehicles. The applicability of the solid waste transfer concept to Lexington County will depend upon the location of the disposal site in relation to the county centroid. The economics of solid waste transfer operations should be fully evaluated. Figure 5.2 presents the relative economics of use of transfer vehicles versus direct-haul packer trucks.

According to the cost estimates, the minimum economical haul distance (break-even distance) using a transfer system is about 7 or 8 miles. At distances less than the break-even distance, it is more cost effective to haul refuse directly with packer vehicles. It should be noted that the transfer cost estimates presented here are quite general and should only be used as economic indicators. A detailed economic comparison

FIGURE 5.1

LEXINGTON COUNTY, SOUTH CAROLINA
SOLID WASTE GENERATION CENTROID

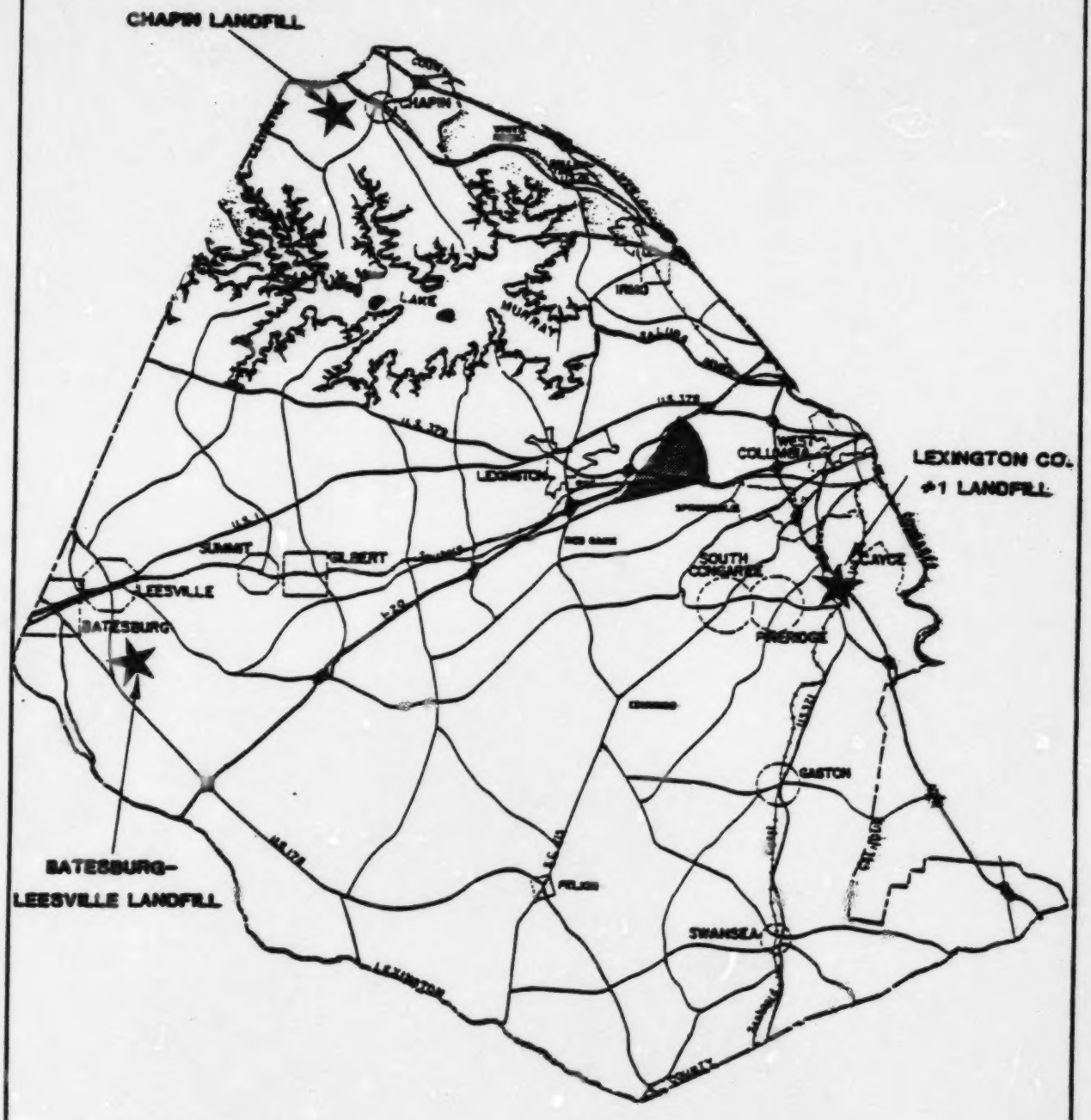

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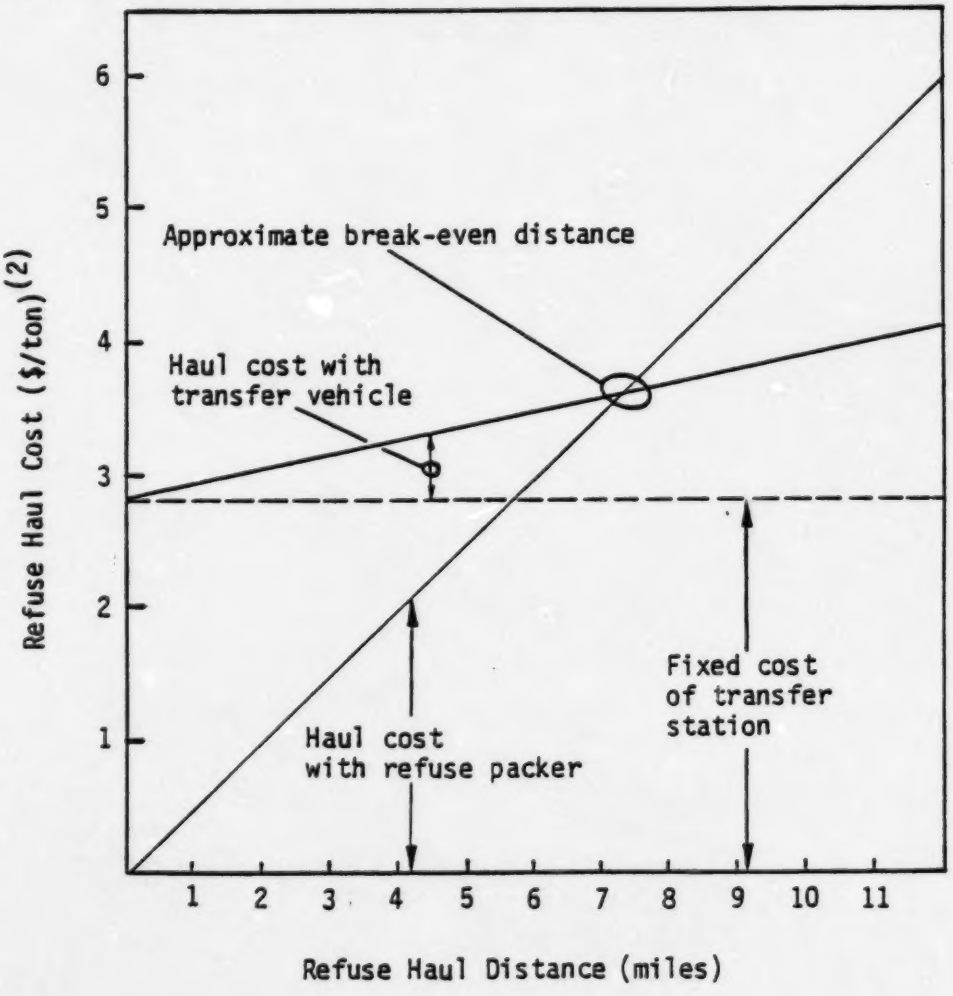
FIGURE 5.2

ECONOMICS OF REFUSE TRANSFER VERSUS HAUL WITH PACKER VEHICLE



(2) Estimated 1980 costs. Accounts for vehicle round-trip.

should be made and non-economic community impacts should be evaluated before deciding to establish a refuse transfer system in Lexington County.

USE OF LANDFILL OPERATED BY ANOTHER ENTITY

The closest landfill facility to Lexington County is the Richland County Landfill. At this time, disposal in the Richland County Landfill is not an attractive alternative to Lexington County due to haul costs, landfill-life, and disposal costs involved.

INCINERATION

Mixed municipal solid waste is composed largely of combustible materials. On the basis of weight, more than 75 percent is combustible, but more important from the point of view of disposal is the fact that 65 to 90 percent of the volume can be eliminated by means of thermal reduction. Historically, thermal reduction has referred exclusively to incineration carried out mostly in refractory-lined chambers. Recently, however, solid waste disposal technology has found many new ways of thermally treating refuse to utilize its energy value. This includes the development of steam-generating (waterwall) incinerators, pyrolysis technology, and various ways to use refuse as a fuel.

Energy recovery from refuse incineration is discussed in Chapter 6. In this chapter the discussion is restricted to the disposal of solid wastes. The incineration of municipal solid waste is a costly and complex operation which is complicated by variations in the quantity and characteristics of the refuse to be processed. Incineration without energy recovery is currently not a financially attractive alternative if land is available for sanitary landfilling. The capital costs of an incineration facility are high, and the operating costs are commonly much higher than operational costs for sanitary landfills. Refuse incineration is also not an ultimate disposal method as ash residue and air pollution residues will require disposal.

CHAPTER 6
RESOURCE RECOVERY

Another solid waste disposal option for Lexington County is resource recovery, that is, the recovery of useful materials and energy from the solid waste stream. In this chapter, the options available to the county for resource recovery are described.

MATERIALS RECOVERY

Municipal solid waste (MSW) contains several materials that can be recovered and used to replace virgin materials in the manufacture of various products. Materials most commonly recovered from MSW are:

- Metal
  - White goods (e.g. refrigerators)
  - Tin cans
  - Aluminum (e.g. cans, foil)
- Paper
  - Newsprint
  - Corrugated
  - Office grades
- Glass (containers).

Materials recovery provides a community with cash revenue while reducing waste flows to its landfill. A successful materials recovery system requires reliable markets that are willing to accept materials of the type and purity that the community can recover; the recovery system must also be appropriate for the community's wastestream and solid waste practices.

The following subsections present brief descriptions of the most common approaches to materials recovery, in order of increasing complexity, and a summary of market options for several materials.

Approaches to Materials Recovery

Ordinance. A municipal landfill may refuse to accept a particular waste type if the municipality passes an ordinance and controls traffic at the disposal area. This approach is practical when there is a way of recoverying the diverted material (e.g. junk autos). In the past, ordinances for junk autos have stabilized the junk auto market and increased the prices of junk autos. Other categories of waste can be excluded from the landfill if outlets are available in the long term. For example, corrugated paper generated by industries or commercial establishments could be sent directly to paperstock dealers; white goods generated by citizens could be picked up by special arrangement with a local scrap dealer; or clean rubble from demolition projects could be directed to land reclamation areas where "clean fill" can be safely used.

Disposal Area Segregation. With this approach, uncontaminated waste streams delivered to a landfill, transfer station, or processing facility are stored separately from other waste, for later sale or reuse. Some of the materials stored in this way, and some typical methods of handling them, are shown in the following table:

Material	Method/Use
Trees, waste lumber	Stored in designated area. Available to citizens as firewood.
Brush	Chipped by municipality. Available for public works or citizen use.
Leaves	Windrow composted by municipality. Compost available for public works or citizens use.
Tires	Stored in designated area. Portion to tire recappers; remainder stored for future potential energy recovery.
White goods; miscellaneous bulky ferrous metal	Stored in designated area. Sold to to scrap dealers.

Stabilized* sewage sludge	Stored in designated areas. Used as topsoil blender for final landfill cover.
Incinerated sludge ash	Blended with soil and used as daily landfill cover.

Recycling Centers. Of all methods of materials recovery, direct delivery of materials by citizens to recycling centers is best known and most widely practiced. The largest portion of the post-consumer wastes recovered is delivered to recycling centers. Centers can be established at solid waste disposal areas, transfer stations, or other convenient locations; they may be staffed by volunteers, or run by public or private companies. The materials recovered at recycling centers are those commonly found in residential refuse (e.g., glass, newsprint, aluminum, tinned steel cans).

The major advantages of using recycling centers are their simplicity, low start-up costs, and the high quality of the material recovered. However, few communities can achieve a waste stream reduction of more than 5 to 10 percent. The method is most attractive to communities that are unable to establish curbside pickup programs, described below.

Curbside Pickup. With this approach, source-separated materials are left at curbside for recovery at prescribed intervals. Householders store the source-separated materials--e.g., newspapers, glass separated by color, aluminum containers or, possibly, a mixture of cans and glass separately from mixed refuse. In one variation of this method, one or more materials are set out weekly with the mixed refuse on the normal collection day; collection crews place the recycled materials in racks mounted on (or trailers towed by) the refuse collection vehicle, or separate crews collect recyclables with special vehicles. Other variations are less frequent separate collections by municipal crews or private contractors, or infrequent collections by volunteers (e.g., seminannual newspaper "drives" by Boy Scouts or Girl Scouts).

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*Stabilized according to state environmental and public health regulations. Authorized methods may include digestion, lime stabilizaiton, and composting.

Curbside collection can recover yields of medium-to-high-quality material amounting to 10 to 20 percent of the waste stream. In well-run programs the cooperation of large percentages of residents has been maintained, and collection costs have been offset by materials sales and decreased disposal costs. However, the method is normally suited only to municipalities having organized collection systems and the capability to manage such a complex undertaking. A curbside source-separation program can complement an energy recovery system by 1) increasing the total tonnage recovered, i.e., decreasing amount to be landfilled; 2) decreasing the tip fees that the energy recovery system must charge a town, especially when large hauls are involved; and 3) reducing the glass content of the waste stream and, hence, reducing abrasion of plant machinery and ash content of the fuel.

Postincineration Recovery. Although somewhat less complex than preincineration or "front-end" recovery, postincineration recovery yields fewer products, less tonnage, and lower market values. Some grades of ferrous metals may be recoverable after burning, with magnetic and simple cleaning techniques. However, ferrous recovered in this way may be damaged, and its market acceptance and price will be low. Other materials, such as glass and ash, have been recovered on an experimental basis after incineration but not under commercial operating conditions.

Front-end Separation. Several materials can be recovered from mixed refuse, using a series of mechanical processes; however, extraction of saleable materials from a mixed waste stream is technically difficult. Front-end separation involves expensive, state-of-the art equipment, and a throughput tonnage of more than 1,000 TPD is necessary to defray the high operating and capital costs. Even with this throughput, front-end separation usually cannot be justified, except as a byproduct of refuse-derived fuel (RDF) preparation. Ferrous extraction, however, may be economically practiced on a small scale, because the technology for magnetic separation is simple and widely used. But even with ferrous recovery, product quality, markets, and economics are uncertain. Overall, front-end materials separation is probably not suitable for Lexington County.

Material Markets

This section presents brief descriptions of the markets for ferrous metals, glass, aluminum, and paper. Normally, communities sell recovered materials to the secondary materials industries rather than to primary markets, (i.e., industries that actually consume the material, such as steel mills or paper plants), because most municipalities do not generate sufficient tonnages to be able to negotiate with and ship directly to consumers. (Glass is an exception because most glass plants will purchase directly from generators in any quantity.)

Ferrous Metal. Most scrap metal dealers will buy any clean ferrous product that can be resold to iron foundries or steel mills. Such products include junk autos, white goods, tin-free ferrous separated from mixed waste, and tin cans. Scrap prices fluctuate rapidly on a national and regional basis. Moreover, local prices depend on the amount of handling and upgrading required and on competition in the local market.

Eight purchasers of metal scrap were contacted. Table 6.1 shows the July 1980 buyer prices for different types of scrap metal convenient to the Lexington County area. Half of the buyers would provide a scrap container service, leaving and picking up containers as needed. The other half specified that the scrap must be brought by the seller to the facility. The price ranges given by some buyers indicate some fluctuation due to scrap quality. In all cases, the metals must be type-separated to bring the highest price.

For tinned steel cans with less than 5-percent contaminants by weight, a detinner may be a better market than a scrap metals dealer. A small community would sell through a dealer, however, because direct sales require a minimum shipment of one full rail car. Detinners recover the tin, which is worth more than $8 per pound, and upgrade the ferrous portion to approximate the value of a "Number 1 Dealer Bundle," a scrap grade that has averaged near $100 per ton in recent years. The major detinners, Vulcan Materials and MRI Corporation, have widely

TABLE 6.1

BUYERS OF SCRAP METAL

July 1980 Prices

Buyer	Location	Container Service Provided(1)	Ferrous Metal Price $/ton	Copper Price $/ton	Brass Price $/lb	Lead Price $/lb	Aluminum Price $/lb	Miscellaneous
Columbia Steel & Metal Co.	Columbia	X	25-60	0.50-0.70	0.30-0.50	0.25	0.25-0.30	appliances
Katz Bros.	Columbia	X	20+	0.50	0.25	0.15	0.25	
American Metal Processors	Columbia	X	20	0.50-0.60	0.28-0.45	0.10	0.25	
Southern Junk Co.	Columbia	X	15-20	0.55	0.15-0.35	0.18	0.25+	
Chatham Steel Corp.	Savannah		16-30	0.50-0.60	0.5	0.10	0.17-0.22	
Owen Industrial Products	Lexington		up to 38	0.40-0.50	0.16-0.25	-	0.15 no cans	appliances $32/ton Cars
Reynolds Alum. Recycling Center	Columbia	will pick up for loads over 800 lbs.					0.30 both cans & scrap	
Your Community Recycling Center	Columbia						0.32 cans	$40/ton for steel cans

(1) Scrap containers left and picked up by the buyer as needed.

scattered facilities (e.g., Baltimore, Maryland; Tampa, Florida) and are the closest existing detinning plants that would accept postconsumer tin cans. Given these long distances, shipping costs might exceed the value of the cans, which currently ranges from $25 to $35 per ton.

Glass In recent years, glass bottle makers have recognized waste glass (cullet) as an excellent raw material. After cleaning to very exacting specifications, cullet is easier and less expensive to use than virgin materials, saves energy, and tends to increase production. Some plants use all the cullet they can get and have even installed equipment to remove metallic contaminants, such as bottle caps and neck rings; other plants are still experimenting with samll quantities. Current prices for clean, color-separated cullet range from $25 to $45 per ton.

Three buyers of reclaimed glass were contacted. Three are in the business of glass container production (Indian Head, Inc., Laurens, South Carolina; Ball Co., Asheville, North Carolina; Owens-Illinois, Inc., Winston-Salem, North Carolina). The reclaimed glass buying policies of all these were essentially the same.

1. Only container glass will be purchased (jars and bottles).
2. Glass must be relatively clean and empty (no caps).
3. Glass must be separated by colors.
4. Glass must be delivered to the plant.

Table 6.2 summarizes the price information obtained from the glass recyclers contacted. Also given is the approximate haul distance and the break-even distance. It can be seen that for the three buyers the haul costs are less than the price paid for the glass.

A fourth glass buyer was the Tally Company in Aiken, South Carolina. Currently the Tally Company buys glass from private citizens for $5/ton. The company requires caps to be removed from the glass but does not require labels to be removed. The company encourages the sellers to separate the glass by color but does not absolutely require it.

TABLE 6.2

BUYERS OF RECLAIMED GLASS

Location[1]	May 1980 Price ($/ton)	Haul Distance[2] (miles)	Break-even Distance[3] (Miles)
Indian Head, S.C.	30	70	240
Ball Co., N.C.	30	155	240
Owens-Illinois, N.C.	30	170	240

(1) All buyers require:

- Only container glass (no flat glass, mirrors, etc.).
- Glass must be relatively clean, empty and without caps.
- Glass must be separated by colors (clear and green).
- Glass must be delivered to the plant.

(2) Approximate driving distance from Cayce, S.C. to each reclaimed glass buyer.

(3) Maximum economic haul distance assuming $0.125/ton-mile.
Further distance requires more haul cost than price paid for glass.

Aluminum. Aluminum cans, foil, and other relatively uncontaminated aluminum scrap are readily saleable and can be shipped long distances because of aluminum high value per pound. Nonferrous dealers are the major market for recovered aluminum. The closest nonferrous dealers identified are listed in Table 6.1.

The major aluminum companies will also provide markets for aluminum scrap, either at their plants or through periodic local visits. Reynolds Metals, in Richmond, Virginia, is very active in postconsumer aluminum recycling. The current price paid for clean scrap aluminum (F.O.B. Lexington County) is between $450 and $500 per ton.

Paper. Two types of potential buyers for reclaimed paper were contacted. One type is firms which are in the business of buying and selling waste paper (stock dealer), and the other type consisted of paper mills which buy waste paper for their own use (recycler).

Paperstock dealers will normally purchase all paper grades that can be extracted from the waste stream at specified levels of quality. Prices for the better grades--tabulation cards and computer printout paper--are higher and more stable than those for the lower grades, such as newsprint and corrugated. Newsprint and corrugated can be sold at "spot" prices, which reflect the current market, or via contract, with a floor price. The contract approach guarantees the community revenue from its paper, even when the market is glutted, but will not provide the highest prices when the market is strong. Recent prices offered by dealers (F.O.B. local community) have low ranges--$10 to $20 per ton for newspapers mixed with magazines. Clean newsprint commands a somewhat higher and more stable price.

Paper stock dealers close to Lexington County include: Consolidated Fibers and Paper Stock Dealers, both of Columbia.

The price paid for different types of paper is presented below:

Stock Dealer Waste Paper Price Summary

Dealer	Newspaper Price 1980 ($/ton)	Corrugated Paper Price 1980 ($/ton)	Mixed Paper Price 1980 ($/ton)	Computer Punch Card 1980 ($/ton)	
				Mixed	White
Consolidated Fibers	35	35	--	80	140
Paper Stock	35	30	5	80	140

During the past year.the waste paper market has been relatively stable, but the dealers have suggested that when planning a recovery program, the organizers should be prepared for occasional minimum prices of $25/ton for corrugated, and no market at all for newspaper or mixed paper.

Three direct recyclers were contacted. Of the three, only one is presently buying wastepaper. Kimberly Clark of Beach Island, S.C. buys through intercompany purchases. Deerfield Specialty Papers, Inc., of Augusta buys waste paper from time to time but is not doing so currently. The Container Corporation of America, located in Chattanooga, purchases paper weekly at their plant. The seller is responsible for shipment of the paper. Current prices are given in Table 6.3, along with the haul distance and "break-even" distance. As can be seen from the table, computer punch cards are the only type of paper that could be economically transported to Chattanooga . A comparison of the net Chattanooga paper mill price paid and the price paid by the Columbia stock dealers show that, despite the higher price paid in Chattanooga, transportation expenses exceed the price difference.

ENERGY RECOVERY

Commercially demonstrated resource recovery technologies exist which can convert from less than 100 to greater than 2,000 TPD of MSW to useable energy. This energy may take the form of RDF for firing in solid fuel fuel boilers; low-temperature steam for manufacturing processes and heating/cooling applications; high-temperature gas (air) for drying or furnace applications; and turbine-quality steam for electricity production.

TABLE 6.3

PAPER MILL WASTE PAPER PRICE SUMMARY

Paper Type	May 1980 Price(1) ($/Ton)	Haul Distance(2) (Miles)	Break-Even Distance(3) (Miles)	May 1980 (4) Net Price
Mixed	19	355	152	NE
Newpaper	31	355	248	NE
Corrugated	35	355	280	NE
Computer Punch Cards	160	355	1280	116

(1) Information for sale to Container Corporation of America (price paid for paper delivered to Chattanooga).

(2) Approximate driving distance from Mid Lexington Co., South Carolina to Chattanooga, TN.

(3) Maximum economic haul distance (assuming $0.125/ton-mile). Further distance requires more haul cost than price paid for paper.

(4) May 1980 price minus haul cost (assuming $0.125/ton-mile).

(5) NE - not economically feasible.

The feasibility of recovering energy from solid waste depends on the presence of five basic ingredients:

1. Potentially viable energy buyers who could use all or most of the energy recovered from the available processible waste.* These buyers typically have the technical capability to use recovered energy; rely on high cost fuels such as natural gas or oil; operate continuously (three shifts, 5, 6, or 7 days per week); are financially healthy and viable over the long term; are located near both the available waste supply and a suitable site for a resource recovery facility; and are interested in the concept of resource recovery.

2. A sufficient tonnage of processible solid waste, from which enough energy and/or materials could be recovered to meet the requirements of one or more potentially viable buyer.

The economics of resource recovery are based primarily on energy output and revenues, so sufficient processible (combustible) waste must be available to provide adequate revenues. Because as much as 35 percent of the waste stream may be oversized or noncombustible materials, and because a portion of waste generation typically cannot be captured, care must be taken in determining the appropriate capacity for a given resource recovery system.

3. Potentially available sites that are well situated with respect to the shipment of solid waste and the delivery of energy to prospective buyers. These sites must be environmentally and physically suitable. For systems producing hot water, steam, or high-temperature gas, the site must be contiguous to the energy customer.

4. Resource recovery technologies that can reliably process available waste and produce energy and/or saleable materials in the form, quantity, and quality required by prospective buyers.

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*Processible solid waste is that tonnage which could be processed in a a resource recovery facility. Unprocessible materials include oversized bulky waste (e.g., large metal objects, rugs) and white goods.

Because the prospective energy market will require energy continuously and waste transport and disposal capacity is typically limited, any resource recovery system must have a high reliability.

5. A total disposal cost that is competitive with the costs of alternative disposal methods available to participating communities.

Energy recovery is one of several environmentally sound solid waste management options. The economic attractiveness of resource recovery must be evaluated against the costs of other environmentally suitable disposal options.

If a preliminary feasibility study indicates the presence of these five ingredients, further feasibility work, prior to implementation of a project, is required. More specifically, the local government should:

1. Ascertain the level of interest of prospective energy customers. Perform detailed evaluations of their energy practices and requirements, including detailed energy load profiles with hourly, daily, and seasonal variations; aggregate current and projected fuel costs; and electrical, water, and other utility charges.
2. Establish a weighing program to ascertain that sufficient solid waste is available, and perform an analysis of waste composition to ascertain that the waste has a sufficient energy value to satisfy the requirements of potential energy buyers. In addition, determine the seasonal fluctuations in waste quantity and composition.

If these three tasks confirm the potential feasibility of the projects identified, a detailed feasibility study should be performed. Such a study will enable the decision makers to decide whether to proceed toward resolving project implementation issues, including system performance requirements, risk management, procurement, and financing.

In considering resource recovery, it is important to be aware that:

- As much as 35 percent of the waste stream measured on a weight basis (less on a volume basis) will require ultimate landfill disposal, even if resource recovery is implemented. This waste

includes oversized, bulky materials and noncombustibles, which are diverted from the project, and residues of combustion. The cost of this landfilling must be taken into account in developing the economic projections.

- The lead time for a resource recovery project is significant. For example, implementation of a modular combustion system requires a minimum of 24 months after procurement contracts are executed.
- Until recently, industry viewed recovered energy as lower in quality and less reliable than other types of energy, and expected the price of the recovered energy to be lower. The expectation is beginning to change, as industrial concerns recognize that resource recovery offers them energy self-sufficiency.

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